THE

STRUCTURE AND PHYSIOLOGY

OF

FISHES

EXPLAINED,

AND

COMPARED

WITH THOSE OF

MAN AND OTHER ANIMALS.

ILLUSTRATED WITH FIGURES.

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TO THE RIGHT HONOURABLE

JAMES HUNTER-BLAIR OF DUNSKEY, ESQ.

LORD PROVOST OF THE CITY OF EDINBURGH;

THIS WORK IS INSCRIBED,

AS A MARK OF THAT RESPECT

THE AUTHOR THINKS DUE TO HIM,

ON ACCOUNT OF THE

LIBERAL AND IMPARTIAL SPIRIT

WITH WHICH HE HAS PLANNED,

AND IS NOW EXECUTING,

VARIOUS SCHEMES,

NOT LESS USEFUL THAN ORNAMENTAL

TO THE

CAPITAL OF HIS COUNTRY.

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THE STRUCTURE AND PHYSIOLOGY OF FISHES EXPLAINED, AND COMPARED WITH THOSE OF MAN.

INTRODUCTION.

A Variety of curious circumſtances has occurred to me in examining the ſtructure of fiſhes, ſome of which have been entirely overlooked, and others imperfectly deſcribed by authors. As they relate to points of chief importance in the animal œconomy, I flatter myſelf that an account of them will be not leſs acceptable to the Phyſician than to the Naturaliſt.

By the generic term of Fiſhes, I underſtand that claſs of animals which lives in water, ſwims by the aſſiſtance of fins, and has the water directly applied to the gills, through which organ the whole maſs of blood in the body paſſes in the courſe of circulation.

This definition comprehends the *Nantes Pinnati*, as well as the *Piſces* of *Linnæus*; ſince it will afterwards appear that theſe ought not to be farther ſeparated than as different *orders* of *one* claſs of animals.

The *Raja* ſhall be my chief example of the *Nantes Pinnati*, and the *Gadus* of the *Piſces* of *Linnæus*: but I ſhall occaſionally endeavour to throw farther light on the ſubject, by deſcribing parts of other fiſhes; and, to be better underſtood, I ſhall illuſtrate my deſcriptions with Figures repreſenting the parts of their natural ſize.

I ſhall begin with tracing the blood from their heart, and its return to that organ.

I ſhall next make ſome curſory obſervations on their organs of ſecretion.

I ſhall afterward give an account of their abſorbent ſyſtem; and

D Shall

Shall conclude with fome obfervations on their Brain, Nerves, and the Organs of their Senfes (*a*).

CHAPTER I.

A Defcription of the HEART, VESSELS, and CIRCULATION of the BLOOD, in FISHES.

IN all the fifhes I have diffected there is but one heart, confifting of one auricle and one ventricle; and, from the latter, one artery is fent out, which is entirely fpent on the gills. From the gills, therefore, the returning blood paffes to all the other parts of the body, without the intervention of a fecond heart, as in man (*b*).

So far is generally known: but the whole courfe of the blood has not been traced with fufficient accuracy; fo that feveral curious and interefting circumftances have efcaped notice.

I fhall therefore give a particular defcription of the circulating veffels of the fkate, with which I have found the *Pifces* of *Linnæus* agree in every material circumftance; and I fhall begin with the branchial artery.

SECT. I.

AT the beginning of the branchial artery there are three femilunar valves (*c*), the middle parts of which, analogous to the Corpufcula Morgagni, are much thicker than in man, and illuftrate the ufe of thefe organs in him, as they very evidently affift in preventing the return of the blood when the artery is in action. Between thefe valves and the principal cavity of the ventricle in the fkate, there is a cylindrical canal interpofed (*d*), the coats of which have the fame mufcular texture as the ventricle itfelf; and their contraction co-operating with that of the ventricle, we are thence led, more evidently than in man, to perceive the analogy between the ftructure of the arteries and that of the heart.

The coronary arteries of the heart do not take their rife from the branchial artery, which, like the pulmonary in man, is fpent entirely on their lungs or gills, by five pairs of great branches in the fkate, and by four in the Pifces of Linnæus (*e*).

When

(*a*) To be more readily underftood, I fhall generally apply the terms *fore*, *back*, *upper*, *under*, *inner*, *outer*, in the fame manner as is done in fpeaking of the human body; or, I fhall fuppofe the fifh to be placed erect with its head uppermoft. But in defcribing the ear and other parts of the head itfelf, I fhall fuppofe the fifh in its natural fituation, as the brain and organs of the fenfes have not the fame direction as in man, with refpect to the trunk of the body.

(*b*) If lungs, as well as gills, are found in the Petromyzon and Diodon of Linnæus, it is probable there may be two ventricles in their heart.

In the Sepia, which has been generally confidered as a fifh, but which is with more propriety reckoned a worm by Linnæus, I have, many years ago, difcovered three hearts; of which, and of other curious particulars in the ftructure of this animal, the reader will find an account fubjoined to this Work.

(*c*) See Tab. II. 40. (*d*) Tab. I. Fig. 4. (*e*) Tab. I. Fig. 4. and Tab. XXVI. Fig. 1.

When we take a fuperficial view of the fmall bulk of the gills; when we reflect, that an organ for reftoring momentum to the blood, fimilar to the left ventricle of our heart, is wanting in fifhes; and when, further, we confider the extraordinary fize of the red particles of their blood; we might be tempted, at firft fight, to fuppofe that their branchial artery did not divide into very minute branches, or that it refembled the *rete mirabile* of the carotid artery of the herbivorous quadruped. But a nearer view will undeceive us. For I have found, that, by the elegant fubdivifions and folds of the membrane of the gills, their furface, in a large fkate, is nearly equal to the whole external furface of the human body.

Thus in each fide of the body of a fkate there are four double gills, or gills with two fides each, and one fingle gill; or there are in all eighteen fides or furfaces on which the branchial artery is fpread out. On each of thefe fides there are about 50 divifions, or doublings of the membrane of the gills (*f*). Each divifion has on each fide of it 160 fubdivifions, doublings, or folds of its membrane; the length of each of which in a very large fkate is about one-eighth of an inch, and its breadth about one-fixteenth of an inch (*g*). So that in the whole gills there are 144,000 fubdivifions or folds, the two fides of each of which are equal to the 64th part of a fquare inch, or the furface of the whole gills in a large fkate is equal to 2,250 fquare inches, that is, to more than 15 fquare feet, which have been fuppofed equal to the whole external furface of the human body. When, after a good injection of the artery, a microfcope is applied, the whole extent of the membrane of the gills is feen covered with a beautiful net-work of exceedingly minute veffels.

As fifhes taint the water they refpire, in nearly the fame manner as we taint the air we breathe; it appears that fome matter, either ufelefs or hurtful, or both, is carried off from their blood as it paffes through their gills.

When diftilled oil of turpentine, coloured with vermilion, is injected with moderate force into the branchial artery of a living or recently dead fkate, fome of the colourlefs part of the oil exfudes upon the furface of the gills. But that thefe are the only paffages by which the hurtful matter efcapes, feems very doubtful; as, from Dr Prieftley's experiments, it appears that the colour of the craffamentum of the blood can be changed by the atmofphere, though the craffamentum be inclofed in an ox's bladder and covered with ferum.

S E C T. II.

We fhall next trace the blood from the gills till it returns to the heart.

In the uppermoft gill (*h*), which is fingle, there is but one confiderable vein.

In each of the four double gills there are two principal veins, an upper and under, joined together by a large tranfverfe canal.

The

(*f*) See Tab. I. Fig. 1. 2. (*g*) Tab. I. Fig. 3. (*h*) See Tab. I. Fig. 5. A B C, &c. to W.

The blood iffues from both ends of all thefe veins, but chiefly at the pofterior part, between the throat and upper part of the fpine.

From the trunks of the branchial veins the blood paffes directly to all the other parts of the fifh, by veffels analogous to the branches of our aorta, and which we therefore call Arteries; and the gills and liver are the only organs which are not fupplied by them folely.

SECT. III.

In the fkate the branchial veins join together, and then difperfe branches in the following order (*i*).

The vein A of the uppermoft gill, which is fingle, is joined, by the canal C, to the uppermoft vein of the fecond gill; and then, running inwards and upwards, forms an artery B, which fupplies the parts of the upper jaw, the eye, the nofe, the ear, and gives fmall branches to the fore-part of the brain.

From the uppermoft vein D E of the fecond gill, other fmall arteries F F are fent off to the jaws. After that, a vein K is added, compofed of the under vein H of the fecond gill and upper one I of the third. A little below the joining of all thefe veins, a retrograde artery L, analogous to our vertebral, is fent off to the brain, cerebellum, and top of the fpinal marrow, the branches of which have large and numerous communications with each other, and with the correfponding artery of the other fide; and from them, chiefly, the encephalon is fupplied. Then the trunk M, from which this artery came off, meets at N, with its fellow M, from the other fide; and, about a finger-breadth lower, there is added, on each fide, a vein R, formed by the under vein P of the third gill and upper vein Q of the fourth.

About a quarter of an inch below the meeting of all the above at T, is fent off from each fide, at nearly right angles, a very large artery U, analogous in fome meafure to our fubclavian. A large branch, *a*, from the root of that artery, fupplies fome parts of the lower jaw; then running towards the fore-part of the gills, it anaftomofes freely with the exterior ends of all the branchial veins (*k*), after which it fends branches Q Q Q to the gills themfelves, which feem to me analogous to our bronchial arteries; efpecially as from the fame part the heart receives its coronary arteries (*l*). The reft of the great artery, which I have called like to our fubclavian, fupplies the numerous and large mufcles and fins on the fide of the fifh, as far down as the fins near to the anus.

At laft, to the trunk T before-mentioned, is added a large vein X, on each fide, which conveys the blood from the under vein S of the fourth gill, and both veins V W of the fifth gill (*m*); and we are led by it to a great veffel Y, which now affumes plainly the office of an artery, refembling our aorta defcendens.

From the fore-part of this trunk two large branches *c d*, analogous to our cæliac and mefenteric arteries, are fent off to the chylopoietic vifcera; a fmall branch from which enters the liver, refembling our hepatic artery (*n*).

From

(*i*) Tab. I. Fig. 5.
(*k*) Vide Tab. I. Fig. 5. *a*, et Fig. 4. P R R R R.
(*l*) Tab. I. Fig. 4. S S.
(*m*) Tab. I. Fig. 5.
(*n*) See alfo Tab. III. R S T U V W.

From the fides of the aorta the organs of generation and urine are fupplied by fmall arteries *e e e e*, &c. and from the lower part of the trunk are fent off two lateral branches *f f*, that may be compared to our iliac arteries, and which fupply the mufcles and fins at the lower part of the body.

A middle artery *g* runs ftraight down into the tail, covered and protected by cartilage, and terminates the aortic fyftem.

From the remarkable courfe of the arteries of the heart, and of the bronchial and hepatic arteries, fimilar to that in man, we fee clear proof, that the blood, which, after paffing through the gills, has undergone one circulation, or rather here has paffed through one artery and one vein, is unfit for fome office or offices which are performed by the blood in the heart, gills, and liver.

Nutrition only has been mentioned by authors: but no fully fatisfying reafon has as yet been given, why by one circulation the blood fhould become unfit for this purpofe; and particularly, why the gills or the lungs cannot be nourifhed, though the whole mafs paffes through them.

S E C T. IV.

From the extremities of thefe feveral arteries, the blood is returned to the heart, by veins which in general refemble our vena portarum (*o*) and venæ cavæ (*p*).

When we examine thefe veins more accurately, we find two venæ cavæ, a right and left one, equal in fize and fimilar in fituation, communicating freely by their trunks in the abdomen, and in other places, as in the head, by their branches. In both, the branches are much larger in their courfe than at their terminations; and they, befides, form confiderable receptacles of blood. For inftance, each of the abdominal cavæ has *double* the diameter of the cavæ conjoined at the heart; and, under the place at which the two cavæ communicate, there is a large receptacle of blood covered by the ovarium in the female, and by the teftes in the male (*q*). In like manner, the hepatic veins between the liver and diaphragm form finufes, the diameter of which is ten times greater than that of their openings into the cavæ (*r*).

Upon the whole, they join in the following manner. The veins from the tail, joining with the iliac veins, form the bottom of the two venæ cavæ, Tab. II. 24. Then the veins from the organs of urine and generation are added, 24, 25. At 26 the two abdominal cavæ, which are contiguous, communicate freely with each other. At 27, above the diaphragm, and behind cartilages which refemble our clavicles, the abdominal cavæ join with the veins which refemble the branches of our fuperior cava. At 28, 29, 30, veins from the mufcles of the back and lateral parts form a trunk refembling our right fubclavian vein; to which the internal jugular 33, and external jugular 34, are foon added. A little farther in, the right vena cava hepatica 31, terminates; and this, at 32, is joined to the left vena cava hepatica. The communicating canal alfo receives the blood from a middle

E lobe

(*o*) See Tab. III. XX, Y, ZZ, *aa*, *bb*, *c*, *d*, *e*, *f*. (*p*) Tab. II. (*q*) Tab. IX. V. (*r*) See Tab. II. 31.

lobe of the liver; that organ being divided into three lobes. The two cavæ, 35, at laſt meet; and, after receiving the coronary veins, 37, of the heart, diſcharge themſelves through a round hole with riſing edges, into the back-part of the auricle of the heart.

Within the external jugular veins, and at the termination of the internal jugulars, I obſerve a pair of valves like to thoſe in the veins of the human ſubject: At the termination of the renal veins and large branches of the hepatic veins, we find ſingle membranes fixed by threads from their edges, reſembling the valve of the coronary vein of our heart; and at the termination of the other large veins, eſpecially near the heart, we not only find the orifices contracted, but doublings at their edges, which have ſo far the effect of valves, even in the dead body, that we cannot fill completely all the veins by throwing an injection in at one of their branches; and, between the auricle and ventricle, valves are interpoſed, which perform their office with great accuracy.

SECT. V.

AFTER tracing the blood in its courſe, I compared with each other the coats of the different veſſels through which it paſſes.

When the large branches of the branchial arteries and veins, or the branches of the aorta formed by the latter, were placed contiguous, they were found to agree very nearly in thickneſs, elaſticity, and texture; nor could I perceive that the ſmall branches of the branchial veins differed from the ſmall branches of the arteries, or that any particular place could be pointed out, at which they might be ſuppoſed to ceaſe from performing the office of veins and to begin to do that of arteries. But the coats of their branchial veins, or of the branches of their aorta, ſeem to differ as much from the coats of the veins which compoſe their vena portarum or venæ cavæ, as the coats of our aorta differ from thoſe of our venæ cavæ.

CHAPTER II.

Obſervations on the CIRCULATION of the BLOOD in FISHES.

FROM reviewing the circulating ſyſtem, and reflecting on the colour of the parts of fiſhes, the following concluſions ariſe.

1. As we obſerve that the red particles of the blood are excluded from many parts, as, in white fiſhes, from moſt of their muſcular fibres, which we know have in us numerous circulating arteries diſperſed upon them, it is evident that in them there

there are numberlefs colourlefs arteries; or we find here ftill clearer proof of the exiftence of fuch arteries, than arifes from the infpection of the human body.

2. When we next confider, that from the circulating arteries of their mufcles, liquors muft be fecreted into the interftices of the fibres, in order to prevent their concretion, and to allow of their ready play upon each other, we fee proof that fecerning branches may be fent off from colourlefs arteries; and that it is not neceffary, on account of the want of impulfe *à tergo* in colourlefs arteries, that fecreting veffels fhould come directly from thofe that convey red blood, as Dr Haller fuppofed (*s*).

3. When to this we add an obfervation I have repeatedly made on the blood of animals, to which I had given madder mixed with their food, to wit, that in their ferum, which was deeply coloured, I could not, with the beft microfcopes, perceive the colouring particles, and yet that the colour was excluded from their cornea and from their cartilages, we are led to perceive that the exiftence of defcending feries of arteries has without juft reafon been called in queftion by Dr Haller and others (*t*).

4. As there are few red parts in white fifhes, and yet their venæ cavæ, at their heart, bear nearly the fame proportion to their aorta or branchial artery as in man, we muft conclude, that their colourlefs, as well as their red arteries, terminate in their cavæ.

Hence, by analogy, it may be allowable to infer, that our colourlefs arteries do not end in our valvular lymphatic veins, but in our cavæ; or that our cavæ correfpond with all the arteries which ferve for circulating the blood.

5. From the divifion of the branchial arteries into exceedingly minute branches, we fhould fuppofe, that the force of the ftroke of the heart upon the blood muft be very much broken and loft before the blood gets into the branchial veins; and, in fact, I faw no pulfation in the branches of the aorta of a living fkate. Hence, in the firft place, we may infer, that the branchial veins are not made thick and tough, merely to enable them to refift the *vis à tergo*.

6. As fo much ftrength and elafticity in the branchial veins are not neceffary for merely refifting the force of the blood, or that more ftrength and elafticity than we obferve in our pulmonary veins were not neceffary for receiving or for merely conducting the blood to the other parts of the body, we muft fuppofe that thefe thick, tough, and elaftic coats, are of a living and mufcular nature, and that the progreffion of the blood through the reft of the body of the fifh depends much on their activity.

7. We fhall ftill more readily admit that the mufcular power of the veffels, and particularly of the arteries, is neceffary for the progreffion of the blood, when, proceeding a ftep farther, we obferve a third circle completed in their liver; though, from the fituation of their gills, and the membranous nature of their diaphragm, the motion of the blood in their liver is not affifted by their refpiration, nor does there feem to be any other vicarious external impulfe fitted to forward it.

8. Apply-

(*s*) See Haller Prim. Lin. Phyfiolog. § xlv.

(*t*) Ibid. & Elem. Phyf. tom. i. p. 117, &c.

8. Applying to man what we have obferved of the veffels and circulation in fifhes, we in the firft place receive ftrong confirmation of an opinion I have always taught, That our arteries are of a mufcular nature; and that their activity is effential in circulation, fecretion, and other important offices.

In the next place we will conclude, that the alternate preffure of our diaphragm and abdominal mufcles in refpiration is not, as fome have fuppofed, the principal caufe of the motion of the blood through the liver; but that the motion of the blood and fecretion of the bile depend chiefly on the mufcular ftructure and action of the branches of the vena portarum. Nay, in the large branches of the mefenteric veins and vena portarum of an ox, I can by diffection demonftrate a truly mufcular coat, confifting of two diftinct layers. In the external layer the fibres are longitudinal, in the internal they are tranfverfe or circular (*u*).

That refpiration and other external impulfes affift, is highly probable, as the difeafes of the chylopoetic vifcera are moft frequent in fedentary perfons.

9. In their abdominal venæ cavæ, and alfo between their venæ cavæ hepaticæ and venæ cavæ, there are large receptacles of blood, and the abdominal trunks of the cavæ and feveral of their branches are larger than their terminations.

In the Seal I have difcovered a fimilar dilatation where the venæ cavæ hepaticæ terminate. As in fifhes the preffure of the water upon the gills muft be very much more than the preffure of the air upon the lungs of land animals, fuch receptacles were perhaps neceffary when they defcend to a great depth; juft as in the Seal they are wanted when the refpiration of the air is interrupted by his diving.

There feems, however, to be reafon for fufpecting, that fome other more latent purpofes are accomplifhed by this ftructure. This appears from the analogy of the lacteal and lymphatic fyftems; in which we fhall find afterwards there are ftill larger receptacles.

10. The laft remark I fhall make is, That, the circulation of the blood being carried on in the cartilaginous fifhes in the fame manner as in the offeous or Pifces of Linnæus, and the whole mafs of blood paffing through their gills, they *muft* breathe regularly and uninterruptedly to furnifh blood to the brain and other organs, or they *cannot* poffefs the pulmo arbitrarius as is fuppofed by Linnæus: So that there appears no juft reafon for claffing them with the Amphibia.

In the animals which are commonly reckoned amphibious, to wit the tortoife, the frog, the lizard, and the ferpent, a part only of the mafs of blood paffes through the lungs. In the frog and common fmall lizard (*x*), branches are fent off from the aorta; which, if we may judge from their fize, convey about one third part of the whole mafs. In the tortoife, the ferpent, and fuch of the lizard tribe as have two auricles and ventricles, a greater proportion paffes through the lungs. In the fea tortoife, the heart and large veffels of which are delineated in Table IV. the blood from the lungs paffes into the left auricle, and from it into the left ventricle. From the left ventricle it is tranfmitted, by

tranfverfe

(*u*) See Tab. III.

(*x*) Linnæus, Syft. Nat. G. 122. Sp. 42. and 47.

tranfverfe canals or holes in the feptum between the ventricles, into the right ventricle, where it is mixed with the blood which is fent from the venæ cavæ through the right auricle. All the arteries therefore take their rife from the right ventricle; and the pulmonary arteries are confiderably fmaller than thofe which fupply the place of our aorta (*y*).

In all thefe animals, therefore, every part of the body may receive a confiderable portion of blood, although the refpiration and free paffage of the blood through their lungs be interrupted. Hence they are not under the fame neceffity with the mammalia, birds, and fifhes, of breathing frequently, regularly, or alternately; or they enjoy the *pulmo arbitrarius*.

CHAPTER III.

Of the GLANDULAR ORGANS and SECRETED LIQUORS in FISHES.

WE fhall next confider fome remarkable circumftances relating to the glandular organs and fecreted liquors in fifhes.

SECT. I.

Of Liquors fecreted on the external Surface of Fifhes.

THE furface of fifhes, efpecially of fuch as live in the fea, is defended by a quantity of vifcid flime; a great part of which, as has been long known, is poured out in the offeous fifhes by the branches of two ducts which are placed upon their fides. Thefe ducts, I have obferved, are continued upon the head and upper jaw; and others of a fimilar ftructure are added upon the under jaw (*z*).

In the fkate, numerous orifices, placed pretty regularly over the furface, have been obferved by Steno to difcharge this flimy matter. With refpect to thefe laft, I have remarked fome memorable circumftances. Firft, I have difcovered one very elegant ferpentine canal between the fkin and mufcles, at the fides of the five apertures into the gills (*a*). Farther forwards it furrounds the noftrils; then it paffes from the under to the upper part of the upper jaw, where it runs backwards as far as the eyes. From the principal part of this duct, in the under fide or belly of the fifh, there are not above fix or eight outlets; but from the

F upper

(*y*) See Tab. IV. and the Explanation of it.

(*z*) See Tab. V. 9. 10. &c. to 20.

(*a*) See Tab. VI. and VII. A B C D E F G H I K L M N.

upper part near the eyes there are upwards of thirty fmall ducts fent off, which open upon the furface of the fkin. The liquor difcharged from thefe has nearly the fame degree of vifcidity as the fynovia in man.

But befides the very picturefque duct I have been defcribing, I have remarked, on each fide of the fifh, a little farther forwards than the foremoft of the five breathing holes, a central part (*b*), from which a prodigious number of ducts iffues, to terminate on almoft the whole furface of the fkin, excepting only the fnout or upper jaw. At thefe centres all the ducts are fhut; and in their courfe they have no communication with each other (*c*). In thefe two central parts, or on the beginning of the mucous ducts, a pair of nerves (*d*), nearly as large as the optic, terminate; and, which is a curious circumftance with refpect to them, they are white and opake in their courfe between the brain and thefe ducts; but when they divide, they become fuddenly fo pellucid, that it is impoffible to trace them farther, or to diftinguifh them from the coats of the ducts.

The mucus of thefe ducts is fo extremely vifcid, that it is difficult to fqueeze it out.

When we review the preceding defcription, we obferve,

1*ft*, Not only a very elegant ftructure for the preparation of the mucus; but,

2*dly*, Such a fudden change of the colour of a nerve, that we are tempted to infer, that its continuation is not merely an expanfion of the matter of the brain, but that the texture of the nerve is altered in its courfe.

3*dly*, We fee clear proof, that fome, at leaft, of the organs of fecretion, are fo far from being remarkable for the fmallnefs of their nerves, that an uncommon fhare of nervous energy feems neceffary for them, to enable their veffels to feparate and change the liquors they fecrete.

S E C T. II.

Of the Liquors fecreted into the Cavities of the Cranium, Pericardium, and Abdomen.

It has been long known, that in the greater number of fifhes a watery liquor is found in confiderable quantity within the head, between the dura and pia mater: but the nature of that liquor has not been fufficiently attended to, nor are its ufes in the offeous fifhes fully underftood.

The cavities of the pericardium and peritoneum in all fifhes have been fuppofed by authors to be fhut facs.

But in the fkate and fturgeon I have obferved fome circumftances, both with refpect to thefe cavities and the liquors they contain, that well merit attention.

1. In

(*b*) See Tab. VI. and VII. 9. 9. (*c*) Tab. VI. and VII. 10. 11. 12. 13. 14. 15. (*d*) Tab. VII. 16. 17.

1. In the firſt place, the liquor within the head (*e*) is of a ſaltiſh taſte; and not leſs than one ſixty-fifth part of its weight is owing to ſea-ſalt diſſolved in it; or it contains nearly one half of the proportional quantity of ſalt diſſolved in our ſea-water.

2. Within the cavity of the abdomen or peritoneum of a ſkate, a great quantity of a ſimilar liquor is to be found, but containing ſomewhat leſs of the ſalt, or about one ſeventy-eighth part (*f*).

3. The great quantity and evidently ſalt taſte of the liquor of the abdomen, which I remarked before I examined the liquor within the head, led me to look for paſſages by which I ſuſpected the ſea-water might get into the abdomen; and I ſoon found two holes or paſſages, one at each ſide of the anus, through which a gooſe-quill may be paſſed (*g*). One thing, however, ſtruck me, that within each of theſe paſſages, there is a ſemilunar membrane or valve, ſo placed as to allow liquors to get out from the abdomen readily, but to reſiſt ſomewhat their entrance into it (*h*).

4. Further, I diſcovered, that in the ſkate the bottom of the pericardium is lengthened into the ſhape of a funnel, which divides into two branches, which are tied cloſely to the lower part of the œſophagus, and open into the cavity of the abdomen (*i*). From the obliquity of theſe branches, and their intimate adheſion to the œſophagus, neither air nor water can be forced into them from the abdomen: Hence, unleſs we ſuppoſe that in the living animal they take up the fluid from the abdomen, in the way our puncta lachrymalia take up the tears, which is highly improbable, we muſt conclude that they ſerve to convey the liquor of the pericardium into the cavity of the abdomen.

5. In the Sturgeon, I have likewiſe found two holes or paſſages at the ſides of the anus ſimilar to thoſe of the ſkate (*k*): but, further, I have in this fiſh obſerved a large funnel on each ſide of the abdomen, which at its bottom opens into the middle of the pelvis of the correſponding kidney (*l*).

When we review the foregoing obſervations, we are led to ſuppoſe,

1. That the liquor of the pericardium of the ſkate paſſes, through the funnel and ducts deſcribed, into the cavity of the abdomen.

2. We can have little or no doubt that the liquor in the abdomen of the ſturgeon paſſes into the pelvis of the kidney; for we cannot ſuppoſe that the urine paſſes through the holes deſcribed into the cavity of the abdomen, as the pelves have large openings into the common cloaca, as in other fiſhes.

3. In like manner, conſidering the funnel ſhape of the lower parts of the abdomen, and of the paſſages at the ſides of the anus of the ſkate, and diſpoſition of

(*e*) See in Tab. XXXIV. the ſize of the cavity of the cranium.

(*f*) The quantity of ſea-ſalt contained in theſe liquors was, at my requeſt, examined by my learned and accurate friend Dr Rutherford. One fiſh only was examined.

(*g*) Tab. XVIII. 29. 30. and Tab. XIX. 26.

(*h*) Tab. XVIII. 30.

(*i*) Tab. II. 22. 22. 22. 23. 23. 23. and Tab. XVIII. 10. 11. 12.

(*k*) Tab. VIII. fig. 1. Q. R. S. and Fig. 2. Q. R.

(*l*) Tab. VIII. fig. 1. N. O. P.

of the valvular membranes, we can ſcarcely doubt that the liquor of the abdomen is diſcharged through theſe paſſages.

4. From the quantity of liquor found within the abdomen both of the ſkate and of the ſturgeon, and its ſalt taſte, we ſeem naturally led to ſuppoſe, that a great part of that liquor is taken in from the ſea by the holes at the ſides of the anus; and that the valvular membranes of theſe holes are intended to prevent ſolid bodies from getting in. Nay, we would conclude, with ſtill greater probability, that in the ſturgeon the holes at the ſides of the anus were formed to admit the water, and thoſe that open into the pelves of the kidneys ſerved to diſcharge it again.

5. But to the above concluſions, I apprehend we ought to add, that a conſiderable portion of the liquor we find in the abdomen is ſecreted from the arteries, as it contains much leſs ſalt than the ſea-water. Nay, perhaps we are not to ſuppoſe that all its ſalt enters by theſe holes at the ſides of the anus, ſince we have found a ſimilar degree of ſaltneſs in the liquor between the cranium and brain; which, as no paſſages are known to lead directly from the ſea into the cavity of the cranium, we muſt conclude is ſecreted from the arteries.

Afterwards when I come to treat of the lymphatic ſyſtem of fiſhes, I ſhall endeavour to point out the paſſages by which the ſalt-water may readily enter the hydraulic ſyſtem of thoſe fiſhes.

SECT. III.

Of Liquors ſecreted into the Organs of Digeſtion.

AS theſe animals are cold, it is more evident than in man, that the gaſtric liquor acts as a menſtruum upon their food.

In all of them the liver is large, and of courſe the ſecretion of bile copious (*m*); and in all, organs are found which pour out liquors ſimilar, probably, in their effects to thoſe of our pancreatic liquor. In the ſkate, the pancreas is ſimilar to the human (*n*). In all the oſſeous fiſhes, ſo far as I recollect, inſtead of a pancreas, a number of inteſtinula cæca pour out their contents into the duodenum. In the ſturgeon, an organ is found in its internal ſtructure ſimilar to theſe inteſtinula; but in its outward form reſembling the pancreas of the ſkate; and, which is curious, the whole of it is incloſed in a muſcle, evidently intended to expreſs its contents (*o*).

Some facts alſo relating to the liver ſeem to merit attention.

In notes I wrote many years ago, I find the obſervation, That in the cat fiſh about a dozen hepatic ducts diſcharge bile into the gall-bladder (*p*). In the eel and ſalmon, ſome of the hepatic ducts open into the gall-bladder (*q*), and others join with the cyſtic duct. In the cod, where the gall-bladder is at a diſtance from

(*m*) See Tab. IX. K. L. M. N. and Tab. X.
(*n*) Tab. IX. O. P. Tab. XIX. 20.
(*o*) Tab. IX. *.
(*p*) See Tab. X. *.
(*q*) Tab. XXVIII. G. H. I.

from the liver, a number of hepatic ducts open into the cyſtic duct (*r*). To theſe I would add an obſervation I have many years ago made in the common domeſtic cock, that the trunk of the hepatic and cyſtic ducts have no communication with each other in their courſe, and open ſeparately into the duodenum; but that there are large hepato-cyſtic ducts.

I obſerve, that in all thoſe animals the gall-bladder receives directly or indirectly ducts from the liver. Hence we are led to the inference, that the cyſtic bile is not ſecreted from the coats of the gall-bladder, as the late Albinus and ſome other eminent authors have ſuppoſed, but that it is derived from the liver.

An attention to the effects of cyſtic calculi in their deſcent through the cyſtic duct, ſerves to confirm this concluſion. For although it is perhaps merely poſſible, that when the gall-bladder contains a great quantity of bile, a calculus deſcending from it, and ſticking in the cyſtic duct, may occaſion a fit of jaundice; yet I have ſeveral times found them impacted in the cyſtic duct of a dead body without any jaundice having appeared before death: And in many other caſes, I have obſerved jaundice appear after the patient had been for ſeveral days or weeks racked with pain; owing, I apprehend, unqueſtionably to the ſtones having irritated the cyſtic duct before they got down to the common duct.

Whereas if the gall-bladder ſecreted the bile it contains, every obſtruction of the cyſtic duct ſhould create jaundice.

Nay, in a few caſes where ſtones very completely obſtructed the cyſtic duct, very little bile was found in the gall-bladder.

Laſtly, after tying the cyſtic duct of a living pig, I did not find jaundice produced; nor did the gall-bladder, after ſeveral days had elapſed, appear to be more diſtended than at the time of the experiment: yet jaundice appeared ſoon after taking up the hepatic duct with a ligature, and the duct itſelf was obſerved to be greatly dilated.

S E C T. IV.

Of the Secretions of the Male Organs of Generation.

THE ſtructure of the milt in the oſſeous fiſhes appears to be very ſimple: but in ſome of the cartilaginous fiſhes, as the ſkate, the apparatus ſeems ſtill more complex than in man; for we obſerve, in place of the teſticle, a ſubſtance compoſed partly of white matter like the milt, and partly of ſmall ſpherical bodies. From theſe an epidydimis is produced, chiefly compoſed of convoluted tubes, which terminate in a ſerpentine vas deferens; the under part of which is greatly dilated, and forms, as in birds, a conſiderable receptacle or veſicula ſeminalis. (*s*).

G Conti-

(*r*) See Tab. X. E. E. G. G. H.

(*s*) Tab. XI. I. K. L. M. N. O. P. Q. R. S.

Contiguous to the outer fide of the dilated end of the vas deferens, I have found a bag of confiderable fize filled with a green liquor, which is difcharged into the fame funnel with the femen, and probably at the fame time with it (*t*). As there is no proftate gland, it is probable that this fac fupplies the place of it.

Certain anatomifts, I have been told, contend, that the organs we commonly call *veficulæ feminales* are not receptacles of the liquor fecreted by the teftes, but organs capable of fecreting from their inner furface a prolific liquor, which is mixed with that from the teftes. To fuch, the defcription I have given of a veficula containing a green liquor very different from the liquor of the teftes, which is white, will probably appear a full confirmation of their new doctrine.

Yet I apprehend, that the moft common theory, which fuppofes that the veficulæ are to be confidered as being folely or chiefly receptacles of the femen, is well founded.

This new doctrine is, I am told, founded on two obfervations.

Firft, on examining the liquor of the vefıculæ feminales of a man immediately after death, it was found very different in its appearance from the femen when it is difcharged by a living perfon.

Secondly, that, a confiderable time after caftration, geldings and oxen had been found capable of generating.

But I would obferve here, that although the liquor of the veficulæ feminales is indeed very different in colour from the femen as it appears when difcharged in the ufual manner, becaufe it is then mixed with the vifcid and white liquor of the proftate gland; yet I find it agrees with the liquor in the vafa deferentia as nearly as the cyftic bile does with the hepatic.

In the next place, we certainly know, that, in fome perfons, difcharges of the femen happen very feldom. That the femen may remain in the veficulæ feminales of a caftrated animal a much longer fpace of time, is extremely probable. How long that fpace may be, it will be very difficult to determine.

But fuppofing it were poffible to prove, that, at the time of caftration, there was not a drop of femen in the veficulæ feminales, and yet that afterwards the animal was capable of generating, it would not follow from this, that the veficulæ were not the receptacles of the liquor fecreted in the tefticle. The utmoft amount of our conclufion would be, that the veficulæ feminales, or terminations of the feminal ducts, were capable of fecreting the fame liquor as the beginnings of thofe ducts in the tefticles. Inftances of caftrated animals generating are, however, fo very rare, as to render it improbable that the veficulæ poffefs fuch a power.

When we throw into the fcale the few following facts, the common opinion will be found to receive great additional ftrength.

I have already obferved the refemblance between the liquor in the end of the vas deferens and in the veficula feminalis; we may remark a fimilar correfpondence in the coats of thefe two parts, and in the cells which thefe form. When we

(*t*) See Tab. XII. E. FF. GG. H. I.

we pour a liquor into the vas deferens, it enters the veſicula ſtill more readily than a liquor poured into the hepatic duct does the gall-bladder.

In birds and in the ſkate, the dilated end of the vas deferens ſerves evidently the purpoſe of a veſicula ſeminalis.

In the dog, the veſiculæ ſeminales are altogether wanting: yet the ſtructure of their teſtis agrees with that of other animals of the ſame claſs, or with that of birds; and no other difference is obſervable, except that the ſtructure of the penis is ſuch as renders the copulation tedious.

Upon the whole, it appears that the veſiculæ are receptacles of the liquor ſecreted by the teſticles, calculated to inſpiſſate the ſemen, and thereby render it fitter for its purpoſe, and at the ſame time to prevent copulation from being tedious.

SECT. V.

Of Secretion in the Female Organs of Generation, and of the Nutrition of the Fœtus.

IN the oſſeous fiſhes, the ſtructure of the roe appears to be ſimple, and the ova are ſmall.

In the ſkate, we find an ovarium, containing large yolks; two uterine tubes; an organ in each, from which chiefly the glaire of the egg ſeems to be ſecreted; two uteri, and, within theſe, eggs with horny ſhells (*u*).

The beginning of the uterine tubes is tied to the diaphragm, as in the frog: and hence it is probable that the yolks, before they reach the tubes, float looſe in the cavity of the abdomen, as happens in the frog (*x*); yet I have never found an egg of a ſkate in that ſituation.

The yolk is at laſt conveyed by a duct into the ſmall inteſtine of the fœtus, in the ſame manner as in birds and lizards (*y*).

SECT. VI.

Of the ſwimming Bladder of Fiſhes.

WHETHER, in treating of the ſecretions of fiſhes, an account ought to be given of the ſwimming bladder, and the air it contains, is perhaps a fitter queſtion than at firſt ſight it may ſeem to moſt readers.

On this ſubject, I ſhall content myſelf with ſtating a few facts and queries, leaving the chief circumſtances to be determined by more extenſive examination and experiments than I have leiſure for at preſent.

It

(*u*) See Tab. II. 15. 16. 16. 17. 18. Tab. IX. Q. RR. S. Tab. XIII. EE. FF.

(*x*) Tab. XVII. O. P. Q. R. S. T.

(*y*) See Tab. XIV. O. P. and Tab. XIV *.

It has been long known, that in the flat fifhes there is no fwimming-bladder. In a few long-fhaped fifhes, as in the mackrel, I have alfo found it wanting.

It is likewife known, that in many fifhes the air-bag communicates by a duct with the œfophagus.

On examining this matter, I have found in a fturgeon a round hole, nearly one inch in diameter, in the upper and back part of the ftomach, by which it communicates with a very large air-bag. The hole is furrounded by thin mufcular fibres, placed between the membranes of the ftomach and air-bag, which decuffate at oppofite fides of the hole; and, no doubt, have the effect of a fphincter mufcle (*z*).

In the falmon, I have found a hole fo large as to admit readily the largeft-fized goofe-quill, leading directly through the coats of the œfophagus into the air-bag. The œfophagus in this fifh has a very thick mufcular coat; but the fibres of that coat do not feem to form a diftinct fphincter around the hole (*a*).

In the pike, in different kinds of carp, in the perca arenarea, in the conger, ducts of confiderable length lead from the œfophagus into the air-bag; and if, as in the carp, there are two air-bags, the duct leads to the pofterior bag, from which there is a paffage into the anterior (*b*).

In the common herring, the under part of the ftomach has the fhape of a funnel; and from the bottom of this funnel a fmall duct is produced, which runs between the two milts or the two roes to its termination in the middle of an oblong-fhaped air-bag (*c*.) No valves are found in thefe air-bags.

When we carry our refearches no farther, we very readily conclude, that the air found in the fwimming-bladder has paffed into it through the ducts I have been defcribing. And thefe feem well fuited for the purpofe; for, as in the common horizontal fituation of the fifh their beginning is at the upper part of the ftomach or œfophagus, we can conceive that the air which we fee them take in at their mouth when they afcend, or that the air which may, by fome more latent procefs, be difengaged from the water, is applied to thefe ducts; and that the fifh, by an inftinct of nature, diftinguifhes the irritation of air from that of water, and propels the air into the air-bag, but excludes the water. We certainly diftinguifh air from water contained in our inteftinum rectum.

But I muft next obferve, that in the cod and haddock, although the air-bag is very large, and its fides remarkably ftrong, I have not been able to difcover any communication of it with the mouth, œfophagus, ftomach, or inteftines. No intermediate duct is difcoverable by diffection. The air-bag is not enlarged by blowing into the alimentary canal; nor can we empty the air-bag without burfting it. Further, a red-coloured organ, the furface of which is very extenfive, as it is compofed of a vaft number of leaves or membranes doubled, is found on the inner fide of the air-bag of the cod (*d*), haddock, &c.: but in thofe fifhes where the air-bag communicates with the alimentary canal, this red body

(*z*) See Tab. XV. fig. 1. 2. 3.

(*a*) Tab. XV. fig. 1. and Tab. XXIX. F.

(*b*) See Tab. XV. fig. 2. Tab. XV*.

(*c*) Tab. XV. fig. 3.

(*d*) Tab. XV. fig. 4. 5.

body is either very fmall and fimple in its ftructure, as in the conger eel; or entirely wanting, as in the fturgeon, falmon, herring, carp.

Hence there is fome reafon to fuppofe, that the air may be fecreted from this red body, fomewhat in the way it feems to be fecreted into the fwimming-bladders of aquatic plants, or perhaps into the air-bag of the egg of a bird as the chick grows (*e*).

This, however, I fhall leave as a mere hypothefis, perfuaded that moft readers will rather fuppofe that the cod, haddock, &c. have an air-duct, which has as yet efcaped obfervation.

To fuch, another queftion will occur, to wit, What is the ufe of this red body? Does it, like the gills, receive fomewhat ufeful, or difcharge fomewhat hurtful, to the animal? And are we to fuppofe that the air-bag not only ferves to render the body of the fifh fpecifically lighter, but alfo that the air received into it is of benefit to the conftitution, by adding fomewhat ufeful, or by taking up fomewhat hurtful?

CHAPTER IV.

A DESCRIPTION of the SYSTEM of LYMPHATIC ABSORBENT VESSELS in FISHES.

IN *this chapter*, I fhall defcribe the courfe and terminations of the lacteal and lymphatic veffels; firft, in the nantes pinnati, of which no account has been yet given; and then in the pifces of Linnæus. In a fubfequent chapter, I fhall propofe fuch obfervations and experiments as ferve to throw farther light on the lymphatic fyftem and fubject of abforption in general.

SECT. I.

IN the fkate, my chief example of the nantes pinnati, the tract of the alimentary canal is remarkably fhort (*f*). When we open the fmall inteftine, we obferve fuch large and numerous valvulæ conniventes, that, on a calculation, the length and furface of the villous coat is found to be much greater than at firft fight we would fuppofe (*g*).

The principal lacteal veffels are fituated near the large branches of the cæliac and mefenteric arteries and veins; and the principal lymphatic veffels of the

H affiftant

(*e*) The air-bag of an egg is over the top of the vagina of the hen; and the air it contains before incubation is taken in from the atmofphere after the glaire is covered by a pellicle.

(*f*) See Tab. XVIII. and XIX. (*g*) Tab. IX. E E.

aſſiſtant chylopoietic viſcera, to wit, the ſpleen, liver, and pancreas, attend the chief blood-veſſels of theſe parts (*h*).

The lacteal veſſels and lymphatics of the aſſiſtant chylopoietic viſcera are much larger in proportion to the blood-veſſels than in quadrupeds, birds, or even in the amphibia: their branches communicate with each other freely and repeatedly; and, inſtead of uniting into one or two trunks, they form a right and left plexus (*i*), which are continued undiminiſhed in ſize till they are about to join with the lymphatic veſſels of the reſt of the body. Neither the lacteal nor the lymphatic veſſels are quite cylindrical, but, by being contracted a little in many places, ſeem to be jointed (*k*): So that we ſhould expect to find numerous valves in their courſe, yet theſe are entirely wanting except at the termination of the whole ſyſtem.

A cellular reticular ſubſtance, with which the lacteals freely communicate, is found at the larger curvature of the ſtomach (*l*), but nowhere elſe in the ſyſtem.

Purſuing the right and left plexuſes formed by the lacteals and lymphatics of the chylopoietic organs, we are led upwards, along the ſides and back part of the œſophagus, to the ſides of the ſpine and outer ſides of the inferior venæ cavæ, and near to large veins covered by ſtrong cartilages which reſemble our clavicles, and which therefore may be called Subclavian Veins (*m*). Towards theſe places all the lymphatic veſſels of the body are directed; the lymphatics of the kidneys and organs of generation, with thoſe of the tail and inferior parts, aſcending; thoſe of the fleſh and ſide-fins or wings of the trunk of the body running inwards, and thoſe of the ſuperior parts and of the brain, organs of the ſenſes, heart and gills, deſcending (*n*).

The branches of the lymphatic veſſels form larger angles where they terminate in their trunks than are found in the circulating veins; and the ſmaller branches are connected by tranſverſe canals (*o*).

The large lymphatics of the muſcular organs, near their joining with the lacteals, are collected together in the moſt ſimple manner, or without forming ſuch intricate plexuſes as we have ſeen in the courſe and near to the termination of the lacteal veſſels (*p*); particularly the lymph from the head and thorax is conveyed chiefly by a ſingle trunk (*q*).

At laſt a ſingle veſſel on each ſide of the animal, and in which there is no dilatation or large receptacle of the chyle or lymph, receives all the chyle and lymph, and terminates in the ſubclavian vein, very near its joining with the internal jugular vein, or in the angle nearly which theſe two veſſels form by their joining (*r*). The blood is prevented from getting into theſe two veſſels by a pair of valves placed at the termination of each (*s*).

No

(*h*) See Tab. III. *g* &c. to *q*. Tab. XVIII. and XIX. A B C. &c. to Z.

(*i*) Compare Tab. XVIII. with Tab. XIX. I K L, &c.

(*k*) See Tab. XVIII. and XIX. D E F G H I K L.

(*l*) See Tab. XIX. C D. and Tab. XX. fig. 1. 2.

(*m*) Compare Tab. XVIII. X. and Tab. XIX. R. with Tab. II. 28. to 34.

(*n*) See Tab. XVIII. K L, &c. to X. and Tab. XIX. K L to S.

(*o*) Tab. XVIII. fig. 2.

(*p*) See Tab. XVIII, L. &c. to W.

(*q*) Tab. XVIII. R S T U V W.

(*r*) See Tab. XVIII. X. Tab. XIX. R. and Tab. II. 36.

(*s*) Tab. II. 36. and Tab. XVIII. X. and XIX. R.

No glands, like to our conglobate glands, are found in any part of the lymphatic fyftem of fifhes.

S E C T. II.

I fhall next give a defcription of the lymphatic fyftem of the pifces of Linnæus, taken chiefly from the gadus and falmo, but compared in fome particular points with other kinds of fifhes.

The chief branches of the lacteal veffels of the great and fmall inteftines, and which are fmaller in proportion to the blood-veffels than in the nantes pinnati, run upwards in the mefentery, almoft parrallel to each other, and near the mefenteric arteries (*t*). In their whole courfe they communicate by a vaft number of fmall tranfverfe canals (*u*). At the top of the abdomen near the gall-bladder, the lacteals of the ftomach and lymphatics of the fpleen, liver and inteftinula cæca are added (*x*). The chyle, mixed with the lymph of the affiftant chylopoietic vifcera, paffes, upwards and towards the right fide, into a large receptacle contiguous to the gall-bladder, and between it and the right fide and back part of the lower end of the œfophagus (*y*). From the receptacle of the chyle large canals pafs upwards to right and left, receiving in this courfe the lymph from the organs of urine and generation. Thofe on the left fide are chiefly behind the œfophagus (*z*).

The chyle, mixed with the abdominal lymph, having afcended above the bones which refemble our clavicles, is poured into large cellular receptacles, fituated chiefly between the clavicles and the undermoft of the gills; and which alfo receive the lymph from all the other parts of the body (*a*).

Four lymphatic veffels, which terminate in thefe receptacles, and which have their extremities contracted by a doubling of their internal membranes, chiefly merit attention. The firft conveys the lymph from the middle of the belly, from the ventral and pectoral fins, and from the heart (*b*). The fecond runs up the fide of the fifh parallel to the great mucous duct, and brings the lymph from the principal mufcles of the tail and body (*c*). The third is deep feated, and conveys the lymph from the fpine, fpinal marrow, and upper part of the head (*d*). The fourth lymphatic veffel, or rather plexus of veffels, brings the lymph from the brain and organs of the fenfes, and from the mouth, jaws, and gills (*e*).

Thefe receptacles may therefore be called the common receptacles of the chyle and lymph. The right receptacle communicates freely with the left by large canals, which pafs chiefly behind the heart and œfophagus (*f*).

From

(*t*) See Tab. XXII. fig. 1. 16. 17. 18. 19. 20.
(*u*) Tab. XXII. fig. 2.
(*x*) See Tab. XXII. fig. 1. 21. 22. 23. 24. 25.
(*y*) Tab. XXII. fig. 1. 26. Tab. XXIV. W W. and Tab. XXIX. L.
(*z*) See Tab. XXII. and XXIX.
(*a*) Tab. XXII. fig. 27. &c. Tab. XXIV. X X. Y Y. Z. Tab. XXV. Fig. 1. and 2.
(*b*) See Tab. XXV. fig. 2. X. and Tab. XXIV. Y Y. Z. and Tab. XXVII. N.
(*c*) See Tab. XXIV. *a a b*, and Tab. 25. fig. 2. S. and Tab. XXVII. M.
(*d*) Tab. XXIV. *c*.
(*e*) See Tab. XXIV. *d e f*, and Tab. XXVII. O.
(*f*) Tab. XXIV. *g h*.

From each of thefe receptacles in the falmon, a canal runs downwards and inwards, and opens into the upper end of its correfponding vena cava inferior, contiguous to and on the fore and outer fide of the internal jugular vein. The terminations of thefe canals are contracted, and their internal membranes are doubled, fo as to ferve the purpofe of valves, in preventing the paffage of the blood from the venæ cavæ into the receptacles (*g*). In the cod kind, the receptacles are proportionally larger than in the falmon; and, befides tranfmitting the mufcles of the gills and their feveral nerves, contain the upper cornua of the air-bladder (*h*).

CHAPTER V.

Experiments and Observations on the System of Lymphatic Absorbent Vessels of Fishes.

1. FROM the want of valves in the lymphatic fyftem of fifhes, except at its termination in the red veins, we can inject coloured fluids from the large lymphatics into the fmall; and hence trace the feveral parts of the fyftem much more eafily and diftinctly than in the mammalia or in birds. In the nantes pinnati, where, except in the reticular fubftances of the ftomach, the lymph is contained in veffels nearly of a cylindrical fhape, and remarkably tough, we can trace the lymphatics with ftill greater certainty than in the pifces of Linnæus: For in the latter, from the weaknefs of the fides of the receptacles of the chyle and lymph, their great fize, irregular fhape, and numerous communications with each other, a rupture of them, with extravafation and laceration of neighbouring red veins, happens frequently; and as the injected liquors get thereby into the red veins, we are apt to miftake thefe for lymphatic veins.

I have therefore made my experiments chiefly on the nantes pinnati; and have found, beyond all doubt, that the diftribution of the lymphatic fyftem is univerfal in them: particularly, by injecting the principal lymphatic from their head (*i*), I have difcovered numberlefs lymphatics in their brain, eye, ear, nofe (*k*); in all which places the exiftence of lymphatic veffels has of late been called in queftion by men of eminence.

2. I would next remind the reader of an obfervation I formerly made, That the red veins are, in proportion to their arteries, as large in fifhes as in man or quadrupeds, and yet their blood contains few red particles; and from the veffels of

(*g*) See Tab. XXVI. fig. 1. 2. 11. 11. Tab. XXVII. S. Tab. XXVIII. M. N. Tab. XXIX. P. Q.

(*h*) See Tab. XXII. fig. 1. 32. Tab. XXIV. O. P.

(*i*) Tab. XVIII. R S T U V W.

(*k*) Tab. XXI.

of their mufcles, and of many other parts, thefe particles are in a great meafure excluded: from which I concluded, that their colourlefs, as well as their red arteries, terminate in their red veins.

3. In a great number of experiments, by injecting penetrating liquors into the arteries and lymphatic veins of fifhes, I have found it impoffible to make thefe liquors pafs from the arteries into the lymphatics, or from the lymphatics into the arteries, except where there was a laceration or rupture of thefe veffels; yet I have repeatedly injected their red veins from their arteries.

Hence the lymphatic veins do not feem to be the continuation of the lymphatic arteries of fifhes: or we are led to fuppofe that, as they do not affift directly in circulating the blood, they muft be of ufe by abforbing fluids from the furface, and from the different cavities of their bodies.

4. From a variety of obfervations and experiments, we can convince our reafon, that the human valvular lymphatic veins are a fyftem of abforbents; but in this clafs of animals, I have difcovered that it is poffible to give a decifive ocular proof of the truth of that doctrine, by obferving the effects of injecting fluids from the trunks into the fmall branches of the lymphatic veins.

My firft experiments were made upon the lacteal veffels of the fkate and of the cod. I found that water, and even air which is lefs penetrating, paffed into the cavities of the ftomach and inteftines, but with difficulty; and as I could not, when pufhing my injection, fee the villous coat of thofe parts, I was by no means certain whether the injection was difcharged from the natural mouths or beginnings of thofe veffels, or from the fides of them burft by the force with which the injection was pufhed. I therefore thought of making my experiments upon a lymphatic from the external furface of the body; and I judged that the great lymphatic from the head and fore part of the fkate (*l*) would be the fitteft for my purpofe, as it is large and its coats are remarkably ftrong.

I foon obferved that my fuccefs exceeded my moft fanguine expectation: For although I had no doubt that the lymphatic veins began by open mouths, yet I conceived that thefe muft be fo exceedingly minute, that no clear view could be got of them, and that the colourlefs part alone of the liquors injected would exfude. But inftead of this, I found that not only water, but air, milk, quickfilver, and even oil of turpentine coloured with the powder of vermilion, were difcharged upon the furface of the fkin, by a vaft number of diftinct orifices, placed at regular diftances from each other: yet the force with which thefe liquors were injected was very fmall, and there was no extravafation into the cellular fubftance any where under the fkin, or in the interftices of the mufcles. On the contrary, the preparations of the parts on which thefe experiments were made, give the moft perfect and beautiful view imaginable of the vaft number and extreme fmallnefs of the branches of thofe veffels difperfed upon the fkin, mufcles, brain, eye, ear, &c. no where disfigured by extravafation (*m*). Nay, which

(*l*) See Tab. XVIII. fig. 1. RSTUW.

(*m*) Tab. XXI.

which is very curious, and the caufe difficult to affign, the effufion of thefe liquors upon the furface of the fkin is made upon the upper or back part only of the fifh, where the fkin is remarkably tough and fcabrous; whereas, on the fuppofition of a rupture, the effufion fhould have been chiefly or folely obfervable on the inferior part, where the fkin is thin, fmooth, and much more tender. From the fmall force neceffary to be ufed in thofe injections, from the want of extravafation in the cellular fubftance, and from the regular diftribution of the orifices from which the liquor is difcharged on the furface of the fkin, no perfon ufed to fuch experiments can entertain a doubt that thefe orifices are the natural beginnings of the lymphatic veins.

The only perplexing circumftances that will occur to him are, how to account for their being feen on the upper part only of the fifh, and for their being larger there than we would expect, when we confider the moft approved opinions about the extreme fmallnefs of the mouths of abforbent veffels.

Thefe difficulties, I apprehend, may be much leffened, if not removed entirely, by attending to the two following facts.

Firft, within the echinus marinus efculentus of Linnæus, a large quantity of falt-water is lodged between the inner fide of the fhell and outer fide of the alimentary canal. On carefully examining the outer furface of the fhell, I have difcovered above two thoufand veffels with orifices or mouths at their beginning, vifible to the naked eye, and furrounded with a hard fubftance, fo that they greatly refemble the human puncta lachrymalia. Thefe veffels, after penetrating the fhell, divide upon membranes into a plexus of branches; from the oppofite fide of which other ducts are fent out, which terminate at the roots of the teeth (*n*).

There can be no doubt, therefore, that thefe veffels with vifible orifices abforb from the fea the falt-water which is depofited within the fhell.

Secondly, I have found that the water which is contained in confiderable quantity within the fkull of the fkate, between it and the furface of the brain, contains a large proportion of fea-falt; for the abforption of which the veffels I have defcribed in the fkin feem to be appropriated.

Upon the whole, I apprehend it may be concluded, that to the many arguments which concur in fhowing that the lymphatic veins are a fyftem of abforbents, we may now add the demonftration of fome of the orifices by which they begin in fifhes.

5. It may be worth while to remark, that from the defcription given of the abforbent veffels of the echinus marinus, which belongs to the clafs of worms, we receive proof, that the abforbent veffels form a diftinct fyftem in the worms as well as in the mammalia, birds, amphibia, and fifhes. Hence, too, it is highly probable a fimilar fyftem will be difcovered in the clafs of infects, or will be found to be univerfal in the animal kingdom.

6. As

(*n*) Of thefe abforbents and of the other parts of this very curious animal, I gave a full account in a paper I read to the Philofophical Society of Edinburgh in 1761, which I have annexed to this work.

6. As no valves are found at the beginning or in the progrefs of the lymphatic veffels of fifhes, or in the abforbents of the echinus marinus, we find proof of three very effential particulars:

Firft, That the progreffive motion of the fluids, in their lymphatic veffels from their fmall to their large branches, does not depend on the external preffure of the mufcles, &c.; for, without valves, this would drive the fluids as readily in the direction from their trunks as towards them.

Secondly, We are of courfe led to conclude, that the coats of the lymphatic veffels, however thin they may feem, are truly mufcular.

Thirdly, Although thefe veffels are in life conftantly, or at leaft generally, filled with fluids, and therefore equally ftimulated in their whole extent; yet we muft conceive that their action, contrary to what we obferve of the arteries, muft begin at their orifices, and proceed from the fmall towards the large branches.

7. The obfervations I made in a former chapter on the venous receptacles of the red blood, may be applied to thofe of the chyle and lymph. But, further, as lymphatic glands are wanting in this clafs, it may feem in fome degree probable, that thefe receptacles affift in fupplying their place by the preffure and agitation to which the chyle and lymph are there expofed; and that perhaps arterious fluids are fecreted from their coats, and mixed with the lymph.

8. Our reafon teaches us, that abforbent veffels muft exift in every the moft minute part of the body: But when we view a well-injected preparation of the lacteal or lymphatic veffels of fifhes, we are ftruck not only with the number of their minute branches, but with the number of their anaftomofing canals; many of which enter the neighbouring lymphatics at right angles, inftead of being directed towards the heart; by which means a net-work is produced, fo very intricate, that, when we view a fmall part of it only, it is difficult or impoffible to afcertain what has been the natural courfe of the lymph (*o*).

By the great number and unfavourable direction of thefe anaftomofing canals, the flow of the lymph muft be greatly retarded, to ferve purpofes which it is difficult to afcertain or even to conjecture.

From obferving them, and confidering their effect in retarding the flow of the lymph towards the heart, we fee further proof, that general preffure cannot be a chief caufe of the progreffive motion of the lymph, but that each veffel muft contribute to its progrefs by a well-regulated action.

9. Very numerous and large lymphatics are difperfed upon the gills of the fkate. To this, when we add that fifhes foon die when put into water from which the air has been extracted, and yet that fuch water is capable of wafhing off exhaled matter from the gills, and of taking up phlogifton readily (*p*), we are led to the fuppofition, that the gills or lungs not only difcharge hurtful matter,

(*o*) See Tab XVIII. fig. 2. Tab XXI. fig. 2. Tab. XXIII. fig. 2. and 4.

(*p*) See Cavallo on Air, p. 485.

ter, but ferve alfo to take in from the air, which is mixed with the water, *fomewhat* neceffary for life; the precife nature of which, experiments do not yet enable us to fpecify.

We may, however, obferve, that the colour and quantity of the red particles of the blood, and the heat of animals, are connected with the mode of their refpiration; and that it is as conceivable that the craffamentum of blood immerfed in ferum and inclofed in a bladder, or that blood circulating in the lungs of a living animal, may receive or attract fubtile matter from the atmofphere, as that it may difcharge fuch into it.

CHAPTER VI.

OBSERVATIONS on the LYMPHATICS of the SPLEEN in FISHES, and on the USES in general of that ORGAN.

THE late Mr Hewfon revived a very laudable attempt to afcertain by experiments the ftructure and ufes of the fpleen. He has defcribed certain minute cells in the fpleen unknown to former authors, and fimilar cells in the lymphatic glands.

In a former work, he had reprefented the red particles of the blood as confifting each of a central part or nucleus included in a veficular, together forming a flat body, the fhape of which he compares to that of a fhilling. He contends, that the cells of the lymphatic glands form the central parts, and that thofe of the fpleen add the veficular.

His arguments are numerous, and his conclufions are drawn with an air of demonftration: Yet I fhall endeavour to prove, that neither his conclufions, nor the facts on which they are founded, ought to be admitted.

1. It is perhaps not a little queftionable, whether two kinds of red particles are diftinguifhable in the blood of living animals, very different from each other in fize and fhape, to wit, the central, and what he calls the full formed flat particles.

2. The appearance of cells in the lymphatic glands and fpleen I am well convinced proceeds from an optical deception, of which Mr Hewfon had no fufpicion; for I have found, that any organ of the body exhibits that appearance as readily as thofe glands or the fpleen: nay, Mr Hewfon and Mr Falconer have reprefented the particles of the blood about fixty times the fize of thofe cells, within which, however, they pretended thefe particles are contained (q).

3. Mr Hewfon tells us, that many central particles are to be feen in the blood conveyed by the fplenic artery, but none in the blood of the fplenic vein; whereas

(q) See my Obfervations on the Nervous Syftem, p. 73.

whereas I have not been able to difcover any difference of particles in the fplenic artery and vein either in a pig or in a fkate. Indeed in both, all the red particles appeared to me to be uniform in fize and fhape.

4. Mr Hewfon tells us, that the blood of the fplenic artery coagulates readily, but that of the fplenic vein fcarcely at all: hence he infers, that the lymphatic part of the blood conveyed by the artery is converted into the veficular part of the red particles. But although I think I have obferved that the blood of the vena portarum is lefs frequently coagulated, or fomewhat lefs difpofed to coagulate, than that of the venæ cavæ, yet I cannot perceive that the blood from the mefenteric veins differs fenfibly from that of the fplenic vein.

5. But his great argument, and which may be confidered as his argumentum crucis, is, that the lymphatic veffels of the fpleen in living animals have been obferved to contain the red particles of the blood completely formed. They are therefore confidered by him as ducts from the cells: and it is fuppofed that this circumftance as fully eftablifhes the ufe of the fpleen, as the finding bile in the hepatic duct fhows the function of the liver (*r*).

As a full confutation of this noted argument, I muft point out three plain facts.

Firft, That the lymphatic veffels of the fpleen are nowife remarkable for their number or fize.

Secondly, That when the fpleen and its lymphatic veffels in a living animal are firft laid in view, their contents are pellucid; and they only receive red particles fome time after they have been expofed to the air.

The third fact, which I learned from repeated experiments many years before Mr Falconer's book was publifhed, and which I mentioned in my lectures, is, That the lymphatic veffels of any deep-feated organ, whether in the thorax or abdomen, fimilarly expofed to the air and irritation, take up red particles. Hence after opening the cavity of the abdomen of a living animal, and fome time thereafter the upper end of the thoracic duct, I have found many red particles mixed with the contents of that duct. To inveftigate all the caufes of this fact would be foreign to our purpofe: but one caufe readily prefents itfelf; I mean, that the application of the cold air irritates and inflames the deep-feated organs; and in confequence of the inflammation, there is an effufion of the red matter of the blood into the cellular membranes, whence it is taken up by the abforbent lymphatics; which too, affected by the irritation, muft be fuppofed to abforb with more than common vigour.

6. In fifhes, and particularly in the fkate, Mr Hewfon has reprefented the red particles of the blood much larger than in man; and of courfe the cells of the fpleen, in which thefe are faid to be completed, ought to be very eafily feen with the microfcope: but this I have not found to be the cafe. Neither in two or three fkates in which the circulation of the blood was going on, though in a languid way, could I perceive any red particles in the lymphatics of the fpleen; which

(*r*) See M. Falconer on the Blood, &c. fect. 103.

which in this animal are, in common with the reſt of the ſyſtem, large, and readily appear on opening the abdomen.

Further, the ſpleen is in fiſhes as remarkably dark coloured as in man, and, in proportion to the reſt of the body, as large; nay, in the ſqualus ſquatina, or angel fiſh, I have obſerved two large ſpleens, one attached to the ſmall and the other to the large curvature of the ſtomach; yet there are few red particles in their blood: On the other hand, in the ſturgeon, where there is much more redneſs in the fleſh, and many more red particles in the blood, than in the cod or ſkate, although I have found not fewer than ſeven ſpleens, yet the largeſt of theſe, in a ſturgeon near ſix feet in length, does not in bulk exceed a dried horſe-bean; and the other ſix are none of them larger than a dried garden-pea. Facts which ſuit ill with the theory propoſed.

Upon the whole, therefore, Mr Hewſon appears to have left this part of phyſiology involved in nearly the ſame obſcurity in which he found it.

He likewiſe treated with ill-placed ridicule the common opinion, that the ſpleen is ſubſervient to the liver: For even ſuppoſing that one uſe of the ſpleen had been, as he contended, to complete the red particles of the blood; ſtill, as its venous blood paſſed not into the vena cava, but into the vena portarum and liver, which we cannot ſuppoſe to happen in vain, it would have followed, that the ſpleen was alſo ſubſervient to the liver, although we ſhould not have been able to ſpecify the particular nature of the ſervice it performed.

CHAPTER VII.

Of the firſt Discovery of the System of Lacteal and Lymphatic Vessels of Fishes, Birds, and Amphibious Animals.

I Shall take this opportunity of eſtabliſhing, in a few words, my claim to the firſt diſcovery of the exiſtence of the lacteal and lymphatic ſyſtem in birds and amphibious animals, as well as in fiſhes, in oppoſition to the pretenſions of the late Mr Hewſon.

In a paper I publiſhed in 1770 (s), I proved, "That in 1758, I obſerved a "veſſel in the meſentery of the common cock, which I ſuſpected to be the "trunk receiving the lacteal veſſels.

"In April 1759, when treating in my Courſe of Lectures of Comparative "Anatomy, I obſerved in a cock what looked like lacteal veſſels collapſed, and "of a bluiſh colour, which ſeemed to terminate at the back-bone between the "teſticles."

I

(s) State of facts concerning the paracenteſis of the thorax on account of air effuſed, and lymphatic veſſels in oviparous animals.

I not only mentioned but ſhowed theſe publicly to the ſtudents of anatomy; and I at the ſame time ſaid, that Dr Cullen had lately told me that Mr John Hunter had ſeen lymphatic veſſels on the neck of a ſwan: And from the two obſervations conjoined, I concluded that fowls had lacteal and lymphatic veſſels like our own.

"Next winter, on April 23d 1760, I diſcovered lymphatic glands on the "neck, blew them up, and valvular lymphatics from them, terminating in the "ends of the jugular veins."

After ſhowing theſe publicly to the ſtudents, I repeated what I had mentioned the preceding winter, but now ſpoke with greater firmneſs concerning their lacteal veſſels, as I always conſidered the lacteal and lymphatic veſſels as different branches of the ſame general ſyſtem. Thus in 1757, I had treated of both under the name of Venæ Lymphaticæ Valvuloſæ (*t*).

The following day, to wit, April 24th 1760, "I diſcovered a whole ſyſtem of "lacteal and lymphatic veſſels in a ſkate fiſh, running towards the heart on the "left of and above the vena portarum; and from theſe the auricle of the heart "was blown up. They are proportionally larger, but have fewer valves than "in man."

This obſervation being made in the forenoon when diſſecting for the ſubject of a lecture on fiſhes, was of courſe mentioned publicly to the ſtudents that day.

In the ſummer of the year 1761, I gave to a dozen living cocks by the mouth different kinds of food, and the food of ſome of them I tinged with madder, ſaffron, rhubarb; or I injected tinged liquors into their inteſtines by a hole I cut in them, without obſerving that thoſe coloured ſubſtances entered their lacteal veſſels.

In the ſame ſummer I repeated my obſervation of the lymphatic veſſels and glands in the neck, and noted their appearance as follows.

"In the neck, I obſerve very diſtinctly lymphatics, which paſs through ſeve-"ral glands like to our glandulæ concatenatæ, and open into the bottom of the "internal jugular vein. If a hole is made into the undermoſt gland, and air "blown in, the vein is immediately filled with the air (*u*)."

In ſummer 1765, I diſcovered lacteal veſſels in the meſentery of a turtle; and after injecting the meſenteric arteries with red wax, and their correſponding veins with yellow, I injected the lymphatics with quickſilver.

I demonſtrated this preparation, which I ſtill preſerve, publicly the following winter; and a drawing of it was then made by Dr Palmer, now phyſician at Peterborough in England. An engraving from this drawing was publiſhed in my ſtate of facts, and is republiſhed in this work (*x*).

From 1759 to the preſent year, it has been my practice, in my courſe of lectures, firſt to deſcribe what I had obſerved reſpecting the lacteal and lymphatic veſſels in thoſe animals; and then to point out in the meſentery of the common cock the lacteal veſſels, and in the neck the lymphatic veſſels and the glands

(*t*) De Venis Lymphaticis Valvuloſis, 1757.

(*u*) Next winter Mr Hewſon attended my courſe of lectures.

(*x*) See Tab. XXX.

glands through which they paſs, before they terminate in the internal jugular veins. Nay, as often as I had a little time to ſpare for the diſſection of the parts, I inflated the lymphatic veſſels and glands of the neck; after which, I handed to the ſtudents theſe diſſected parts laid on plates, that ſuch as choſe might take a nearer view of them. I likewiſe have conſtantly, on this occaſion, handed around my preparation of the lacteals of the turtle injected with quickſilver.

Much later, to wit, in October 1768, Mr Hewſon preſented to the Royal Society of London an account of the lymphatic ſyſtem in birds; and in a note added, he ſays, he had ſo long ago as in the winter 1763-64 obſerved lacteals in a turtle.

In a paragraph ſubjoined to the above account, dated December 3. 1768, he adds, That ſince the above paper was put into the hands of the ſecretary, he has diſcovered the ſame ſyſtem in fiſh; and has likewiſe been ſo fortunate as to procure a turtle, whoſe lymphatic ſyſtem he has traced out, and has got delineated.

Accordingly, in June 1769, he preſented to the Royal Society an account of the lymphatic ſyſtem in amphibious animals and in fiſhes.

Not contented with the merit of having merely proſecuted the particular branches of the lymphatic ſyſtem in ſome of the oviparous animals, Mr Hewſon thought proper to aſſume the title of their firſt diſcoverer; endeavouring to perſuade his readers, that although the paragraphs above quoted, the authenticity of which he could not venture to call in queſtion, proved that I had *perſuaſions* and *opinions* of their exiſtence; yet they did not prove I had *in reality* diſcovered them. And, to give colour to theſe pretences, he has ventured to publiſh notes which he thought ſuited his purpoſe, taken indeed by ſome very reſpectable ſtudents who had attended my lectures.

But though theſe notes are palpably erroneous as well as imperfect; and that the principal of them, particularly the notes of Dr Morgan, who attended my courſe of lectures at the ſame time with Mr Hewſon, are not taken from my Lectures on Comparative Anatomy when I accompanied my deſcriptions with diſſection and demonſtration, but from a more early part of my courſe, in which, whilſt treating of the lymphatic ſyſtem in the human body, I uſed to mention the lymphatic ſyſtem in the oviparous animals in a curſory way only; yet even theſe, when compared with the preceding extracts, lead to concluſions very oppoſite to thoſe Mr Hewſon has drawn; for they plainly ſhow that he miſrepreſented the following very material points.

Firſt, Becauſe after ſummer 1761 I told the ſtudents that I had not obſerved coloured liquors enter the lacteal veſſels of birds, he repreſents me as acknowledging I had never ſeen the lacteal veſſels; yet he knew that, for three ſucceſſive years preceding that time, I had ſhown collapſed bluiſh veſſels in the meſentery of fowls, different from the branches of the meſenteric artery and vein. He ſaw me demonſtrate theſe in the winter 1761-2; and he muſt afterwards have certainly

certainly known, as I did, that the veſſels I then, and every year ſince, pointed out, were *in reality* the lacteals of fowls. Nay, before he publiſhed, he himſelf had found by experiment, that the chyle in the lacteals of fowls was always colourleſs; and therefore he knew, that my not ſeeing coloured chyle was no proof that the veſſels I had ſeen were not the lacteals.

Secondly, Mr Hewſon, upon the credit of what he knew or might have known to be in Dr Morgan's notes, has aſcribed to Mr John Hunter a diſcovery of mine in 1760; which, ſo far as I know, that gentleman never aſſumed, and from which the exiſtence of the valvular lymphatic ſyſtem in birds was proved, to any perſon who underſtands the ſubject, beyond all poſſibility of doubt or deception: I mean my having, in 1760, firſt diſcovered conglobate glands at the lower part of the neck of fowls ſimilar to our glandulæ vagæ, and having inflated valvular lymphatic veſſels entering theſe at their upper, and coming out at their lower part, to terminate in the internal jugular veins.

Mr Hewſon's arguments, by which he pretended to ſhow that I had not anticipated him in the diſcovery of the lacteals in fiſhes, are equally unfortunate.

That the reader may not think I miſrepreſent them, I ſhall ſtate them in his own words. "Next (ſays he) as to the lacteals in fiſh. To prove that he (Dr Monro) had found thoſe veſſels eight years ago, he (Dr Monro) tells us, that in a note taken from the diſſection of a ſkate on April 24th 1760, he has ſaid, 'He had diſcovered a whole ſyſtem of lacteals and lymphatic veſſels, running 'towards the heart, on the left of and above the vena portarum; and from 'theſe the auricle of the heart was blown up. They are proportionally larger, 'but have fewer valves than in man.'

"Now (continues Mr Hewſon), I will take upon me to ſay, there is nothing in this note which proves whether he had inflated a lacteal or a vein: For what he ſays of the ſituation of the veſſels, and of his blowing up the heart, is equivocal. The only part of the note which appears to characteriſe the lacteals is in reality a miſtake; that is, where he ſays they have valves."

In anſwer to all this, I would obſerve two plain facts. The firſt of which is, that the red veins of the meſentery in fiſhes, as well as in man, do not lead to the heart, but to the vena portarum. When therefore I found that the veſſels I inflated led directly to the heart, I knew them to be for certain the lacteals.

In the next place, the veſſels I inflated were in their appearance totally different from the red veins. They formed a great plexus, or what I have called "a whole ſyſtem of lacteals and lymphatics running towards the heart; were "larger, and appeared to have fewer valves than in man." But Mr Hewſon exclaims they have *no valves;* and therefore would infer that I had not ſeen their lacteals. But ſuppoſing they had no valves, it would by no means follow that I had not inflated their lacteals; becauſe they are in reality not cylindrical veſſels, but are jointed; and of courſe I judged, from the analogy of the human body, that they were valvular.

Further, it has appeared, that within the lacteals of the ſkate there are cellu-

lar receptacles and membranes of a valvular nature; and that, at the termination of the lymphatic fyftem of fifhes in the red veins, the place of which we have found Mr Hewfon had not been able to trace (*y*), there are valves exactly like to thofe in the human body, and which perform their office in the moft accurate manner.

I fhall fubjoin two letters from phyficians of diftinguifhed character, who attended my lectures at critical periods, to wit, Dr Charles Richardfon phyfician at Kingfton in Jamaica, and Dr Adam Kuhn phyfician and profeffor of materia medica at Philadephia.

Dr Richardfon ftudied phyfic in this univerfity from 1755 to 1763, when he received his degree of Doctor of Phyfic, and was confidered by all the profeffors as one of the moft fenfible and intelligent candidates who had ever come before them, and at Kingfton in Jamaica is univerfally efteemed. He had attended my father's courfes in 1756-7 and 1757-8, and my three firft courfes, to wit, 1759-60, 1760-1, and 1761-2; in the laft of which Mr Hewfon was prefent. As the time of his attendance was fo very critical, I wrote to him in 1769, when Mr Hewfon claimed the firft difcovery of the lymphatics and lacteals in birds and fifhes. As I got no anfwer then, I wrote again two years thereafter, defiring him to declare what he remembered to have heard or feen here concerning the lacteal and lymphatic veffels of birds and fifhes. The following is a literal copy of his anfwer.

" SIR,

" You defire me to appeal to my notes and memory, to do you juftice with " regard to the prior difcovery of the lacteals and lymphatic veffels (in birds and " fifh) to the late Mr Hewfon. My manufcripts I had the misfortune to lofe " many years ago: however, it is frefh in my memory, that I was not only as " much convinced of their exiftence in both, before I left the univerfity of Edin- " burgh, as I am at prefent; but that in the year fixty-three I demonftrated " them on the mefentery of a live fhark to Mr Gilbert Turnbull, then my mate " in the Speaker Eaft Indiaman, and to feveral other gentlemen prefent; and " named you as the difcoverer.

" Upon the receipt of your letter, I wrote to Mr Turnbull and two more " friends upon this fubject, whofe anfwers have not as yet come to hand; " which is the reafon I have fo long delayed writing to you. They can now " be of little fervice when they do come, as poor Hewfon's death puts an end " to the difpute; which I am forry to fee terminated in that way, both upon " your account and his.

" This will introduce to your acquaintance Mr Richard Trower, who pro- " pofes to complete his medical education in Edinburgh," &c.

" I am, &c.

" Kingfton, Jamaica,
May 4. 1776.

" CHARLES RICHARDSON.

" For Dr A. MONRO."

After

(*y*) Mr Hewfon, on the Lymphatic Syftem, p. 91. defcribes " a veffel, the termination of the whole fyftem, going into the " jugular vein juft below the orbit;" whereas the real termination is in the venæ cavæ. See Tab. II. 36. Tab. XVIII. X. Tab. XIX. R. Tab. XXVI. fig. 2. 3. and Tab. XXVIII. M, N.

After Mr Hewfon's Appendix was publifhed in 1772, I wrote to Dr Kuhn, afking his teftimony; for as the Doctor had been with Linnæus before he ftudied here, and was particularly attentive to natural hiftory, I thought he would recollect what he had feen more particularly than thofe ftudents who attend chiefly to practical fubjects. He ftudied here in 1765-6 and in 1766-7, and took his degree of Doctor in 1767. His anfwer is literally as follows:

" DEAR SIR,

" I am under infinite obligations to you for the Treatife on the Lymphatics " you were pleafed to fend me, as I never could get the book in this country; " and when I left Europe, not a copy could be purchafed on any account.

" The ftate of facts between you and Mr Hewfon muft convince even preju- " dice that the honour of the invention is due to you. There are feverals in " this country who are convinced of it from attending your courfe of anatomy. " My own teftimony is not of the importance with fome who were in Edin- " burgh before me; but I *remember well* your demonftrating thofe veffels in " birds and fifh publicly in your lectures, at a time numbers came annually " from London, who faw them at your theatre for the firft time.

" Mr L." &c.

" I have the honour to be, &c.

Philad.
July 23. 1773.

" ADAM KUHN.

" For Dr A. MONRO."

CHAPTER VIII.

Of the BRAIN and ORGANS of the SENSES in FISHES.

SECT. I.

Of the Brain in Fifhes, and Nervous Syftem in general.

THE brain of fifhes is fenfibly fmaller in proportion to their body than in the mammalia or in birds; yet the nerves it fends off are as large in proportion to the feveral organs as in thofe two claffes.

In it we find the like principal divifion into brain and cerebellum; and thefe are hollow, or have ventricles within them.

The

The fubdivifions of the brain and cerebellum, or their tubercles and lobes, are more numerous than in the mammalia or birds; and in the various genera of fifhes, the differences of thefe are fuch, as to fhow the vanity of attempting to determine the office of each lobe or tubercle of the brain.

Ganglia are wanting in their nerves.

In one genus of fifhes, the gadus, I have found fpheroidal bodies between the dura and pia mater, and covering the greater part of their nerves, like a coat of mail, in their courfe towards the organs to which they are deftined. That this obfervation may be intelligble to the reader, I have fubjoined Tables reprefenting them (*z*), which I formerly publifhed in my work on the Nervous Syftem.

After thefe few general obfervations on the brain, we fhall proceed to confider the organs of the fenfes, and particularly the nofe, the ear, and the eye; for on thofe of touch and tafte I find little or no room for remark.

SECT. II.

Of the Organ of Smell in Fifhes.

IN all fifhes, external openings or noftrils for fmell are very evident, generally two on each fide in the offeous fifhes (*a*), which, on each fide of the head (*b*), lead to a complex organ, the furface of which is of confiderable extent; and upon them a pair of large or olfactory nerves terminates, with the addition of fome branches from nerves refembling our fifth pair (*c*). In fome fifhes, as in the haddock, I have obferved that the olfactory nerve, in its courfe between the head and the nofe, paffes through a cineritious ball (*d*), refembling the cineritious matter connected in our body to the olfactory nerve within the cranium.

There can therefore be no doubt that they enjoy the fenfe of fmelling: nay, there is great reafon to believe, that, fuited to their furrounding element, they are much more fenfible of odorous bodies diffolved in water, and applied by its medium, than we fhould be, if the application of the object was to be made to our organ of fmell by the fame medium.

(*z*) See Tab. XXXI. XXXII. XXXIII.

(*b*) See Tab. II. 11. Tab. XL. fig. 1. and 2.

(*d*) See Tab. XXXI. fig. 1. K.

(*a*) Tab. XXXI. fig. 1.

(*c*) Tab. XXXI. O O.

SECT.

SECT. III.

Of the EAR in Fiſhes.

§ 1. Of the Ear in the Cetaceous Fiſhes.

IT is well known that the ear of the whale-kind reſembles that of man; and ſeveral authors, particularly Dr Tyſon and Dr Camper (*e*), have publiſhed an account of the ſeveral parts which compoſe it: but I have not been able to procure either of theſe works. I obſerve, from the Commentarii Lipſienſes (*f*), that Dr Camper denies that they have ſemicircular canals; a circumſtance in which I apprehend this eminent author to be miſtaken. He is alſo uncertain whether they have an Euſtachian tube. I ſhall for theſe reaſons, as well as for the ſake of connection, give a ſhort account of what I have obſerved in the diſſection of the phocæna, one of the cetaceous order.

On each ſide of the head there is a round hole (*g*), ſcarcely large enough to admit the head of a ſmall pin, which is the beginning of a long meatus auditorius externus (*h*); at the bottom of which we find a concave membrana tympani (*i*). The membrana tympani is connected to the bottom of the cavity of the tympanum by a chain of ſmall bones, tied together by a reddiſh-coloured membrane. The innermoſt piece, analogous to our ſtapes, has evidently a muſcle connected to it (*k*); a large nerve or portio mollis divides into two branches, and then enters the bone at the bottom of the cavity of the tympanum or os petroſum (*l*): and following one of the branches of the nerve, we are led to the cochlea, which is divided by a ſeptum into two ſcalæ; each of which contains a reddiſh-coloured tube, that is eaſily ſeparable from the oſſeous canal which contains it (*m*).

Following the other branch of the nerve, I obſerved part of the ſemicircular canals; the membrane of which is very thin (*n*), and adheres to the bone which contains it.

The cavity of the tympanum is remarkably large, and communicates freely with other cavities which are analogous to our frontal, ſphenoidal and maxillary ſinuſes (*o*).

A tube, ſimilar to our Euſtachian tube, or iter a palato ad aurem, begins towards

M

(*e*) Tyſon on the Phocæna. Camper acta Harlem. tom. ii. et xvii. in 1765 and 1776.

(*f*) Com. Lipſiens. vol. xvii. p. 460.

(*g*) See Tab. XXXV. fig. 1. F.

(*h*) Tab. XXXV. fig. 5. F G.

(*i*) See Tab. XXXV. fig. 5. I. and fig. 6. I.

(*k*) Tab. XXXV. fig. 6. K L M.

(*l*) See Tab. XXXV. fig. 7. T S.

(*m*) Tab. XXXV. fig. 8. U W. and fig. 9. W Y Z.

(*n*) See Tab. XXXV. fig. 8. X.

(*o*) Tab. XXXV. fig. 6. N O P Q R.

wards the lower end of the fiftula, through which the animal refpires; and, contrary to what we obferve in man and quadrupeds, it gradually enlarges as it runs back towards the cavity of the tympanum, in which it terminates (*p*).

While, therefore, thefe animals float on the furface of the ocean, impreffion is made on the feveral parts of their ear in the fame manner as in man.

The remarkable difference of the fize of the caverns which, in place of the cells of our maftoid procefs, communicate with the cavity of the tympanum, leads us to confider, Whether the effect of the found upon the ear be increafed by that circumftance? or, Whether the chief ufe of thefe caverns may be to render the head fpecifically lighter, and, like fwimming-bladders, to make it rife more readily to the furface of the fea?

As the entry into the external meatus auditorius is fo very fmall, there is reafon to fuppofe that the animal can fhut it when it dives to a confiderable depth, and when the weight of the water might have been in danger of injuring the membrana tympani. And from obferving the fmallnefs and ftructure of the mouth of the external meatus auditorius in the whale, divers may perceive the neceffity of plugging the ears accurately, in order to prevent the overftretching of the membranes of the drums.

§ 2. *Of the Ear in Amphibious Animals, and particularly in the Sea Tortoife or Turtle.*

Before I proceed to give an account of the ftructure of the ear in the nantes pinnati and pifces of Linnæus, I fhall, in a few words, defcribe the ear in the intermediate tribe of the amphibious animals, taking the fea tortoife or turtle as my chief example of the clafs.

In this animal, as well as in the frog and moft others of the clafs, there is no external ear nor meatus auditorius externus; but we find a large Euftachian tube on the back part of the roof of the mouth, near to the articulation of the under jaw with the upper. This tube has a winding courfe behind the condyle of the upper jaw, and leads to a large cavity, refembling (*q*) our cavity of the tympanum (*r*), covered by the fkin of the temple and a tough fubftance with a thin cartilage on its inner fide; the whole of which taken together are nearly one fixth part of an inch in thicknefs (*s*).

To thefe teguments a cartilaginous body, nearly of the fize of a fmall probe, and upwards of three quarters of an inch in length, is connected; and paffes, firft to the bottom of the tympanum, then through a bone, and through another fmaller cavity, in which a watery humour is lodged; and at the bottom of which the cartilaginous body is connected to a membrane which fills a hole (*t*).

Within that membrane or hole a third cavity is found, which lodges three femi-

(*p*) See Tab. XXXV. fig. 4. O. fig. 5. L M N.

(*q*) Tab. XXXVI. fig. 1. H I K. fig. 2. C.

(*r*) See Tab. XXXVI. fig. 2. B. fig. 3. B.

(*s*) Tab. XXXVI. fig. 2. A. fig. 3. A.

(*t*) See Tab. XXXVI. fig. 2. E. fig. 3. E F. fig. 4. B.

ſemicircular canals, to wit, an anterior, a poſterior, and a middle horizontal canal (*u*), and alſo a ſmall ſac, which contains a ſoft cretaceous ſubſtance (*w*).

The ſemicircular canals contain, and are ſurrounded by, a viſcid watery humour.

On the membranes of theſe canals, and on the ſac, nerves are diſperſed (*x*).

When we compare the parts in this animal with the human ear, the cartilaginous body ſeems to ſupply the place of the ſmall bones of our ear; and the membrane to which the inner end of it is connected ſeems analagous to the membrane of our foramen ovale.

The ſac containing the cretaceous matter, with the three ſemicircular canals and nerves diſperſed upon them, reſemble the labyrinth of our ear.

§ 3. *Of the Ear in the Cartilaginous and Oſſeous Fiſhes.*

The ſtructure of the ear in the cartilaginous and oſſeous fiſhes has been ſo little examined, till of late, that, for upwards of two thouſand years, it has been a queſtion whether they poſſeſſed organs appropriated for hearing.

Swammerdam (*y*) mentions a wonderful labyrinth of the ear in fiſhes; but moſt anatomiſts ſince his time contented themſelves with pointing out, as the organ of hearing, ſacs at the ſides of the brain of the moſt common fiſhes containing ſtony ſubſtances, without pretending to ſhow external paſſages leading to theſe ſacs, or the nerves or medium by which theſe ſacs were connected with the brain of the animal.

About the beginning of the year 1779, the learned and accurate Dr Soemmering, now profeſſor at Caſſel, and who at that time did me the honour of attending my courſe of lectures, told me, that the ingenious Dr Camper, in a letter he had received, mentioned his having diſcovered ſemicircular canals in the ears of fiſhes. I therefore determined to look for theſe when I ſhould come to that part of my courſe in which I treat of Comparative Anatomy: And accordingly I found, and ſhowed to the ſtudents, in the month of April following, ſemicircular canals both in the ſkate and in the cod.

In the following month of May 1779, I traced the communication of the ſeveral canals of the ear with each other, and the diſtribution of the nerves upon them; and was alſo ſo fortunate as to diſcover the entry into the external ear of the ſkate, its concha, meatus auditorius externus, and its communication with the interior canals: All which I have ſince annually demonſtrated to the ſtudents in my courſe of lectures.

In the month of Auguſt following, I ſhowed to the Philoſophical Society of this place the tables of thoſe parts in the ſkate and cod which I now publiſh, along with the tables which repreſent their circulating and abſorbent veſſels.

Since

(*u*) See Tab. XXXVI. fig. 3. G H I. (*w*) Tab. XXXVI. fig. 4. C. (*x*) Tab. XXXVI. fig. 4. D.

(*y*) Swammerdam, Bibl. Natur. p. 111.

Since that time, I have received a work by M. Geoffroi, on the Organ of Hearing of Fifhes and other Animals, which was read to the French Academy in 1753, but was not publifhed till 1778; and find that Dr Camper and M. Vicq. d'Azir, previous to the publication of M. Geoffroi, had given an ac-account of many difcoveries on the fame fubject, which they illuftrate by tables (*z*).

In the works, however, of thefe authors, the communication of the canals of the ear with each other has not been fully traced. Little attention has been paid to the nerves which fupply them; and a very principal part, the external meatus auditorius, has entirely efcaped their obfervation *.

I fhall therefore proceed to give a defcription of the ear; firft in the cartilaginous flat fifhes, and then in fome of the oblong-fhaped cartilaginous and in the offeous fifhes. After which, I fhall give an account of a few experiments I have made on hearing in water.

§ 4. *Defcription of the Ear of a Skate.*

In the back part of the occiput, near the joining of the head with the fpine, two holes (*a*), not larger than to admit the head of a fmall pin, are found at the diftance of an inch from each other in a large fifh. Each of thefe leads into a capacious winding canal or concha, which defcribes nearly a complete circle (*b*). The two conchæ are feparated from each other by a thin partition (*c*). Each concha terminates in a funnel, from which a fmall cylindrical canal or meatus auditorius externus is continued (*d*). The meatus is lodged in a hollow left between two thick cartilages (*e*); and as there is no membrana tympani, it opens into a large fac, which contains a white or opake matter, with a quantity of clear watery-looking, but vifcid, matter (*f*). The white fubftance is foft and cretaceous, effervefcing violently with vinegar; has a regular fhape; and yet, in the meatus auditorius externus and concha, generally fome portion of a fimilar matter is found, as if part of it paffed off by the meatus, or was fomehow neceffary for communicating the impreffion of found to the bottom of the ear.

On

(*z*) See Acta Harlem, tom. xvii. 1762. et Mem. de Math. et de Phyf. pres-a l'Ac. R. des Sciences, tom. vi. et vii. 1774.

* M. Geoffroi fays, " L'organe de l'ouie de la raye ne paroit point du tout a l'exterieur, et fon entrée n'eft point " aifée a decouvrir. Cachée fous des mufcles, elle eft placée proche les condyles, a leur partie laterale externe ..... en " la fuivant a l'interieur, on voit qu'elle donne naiffance a deux canaux; l'un fort court, qui penetre dans la cavité du " veftibule, une fente longue, irreguliere, dont les bords font comme dechirés," &c.

And p. 93. Du trou auditif ..... recouvert des mufcles et de graiffe,

Dr Camper, Mem. de Math. tom. vi. p. 194. denies that there is an external opening: " L'organe de l'ouie de la raye " n'a donc aucune communication avec l'air de l'atmofphere; mais il eft enfermé," &c.

And M. Vicq. d'Azir, tom. vii. p. 20. fpeaking of the cartilaginous fifhes or nantes pinnati of Linnæus, fays, " L'or-" gane de l'ouie na point, chez eux, d'ouverture exterieure."

(*a*) See Tab. VII. fig. 1. fig. 2. A A. fig. 3. 4. 5.

(*b*) Tab. VII. fig. 2. B C. fig. 3. 6. 7.

(*c*) See Tab. VII.

(*d*) Tab. VII. fig. 2. *de*. fig. 3. 8.

(*e*) Tab. XXXVII. fig. 2. 16. 17.

(*f*) Tab. XXXVII. fig. 2. 18. and fig. 3. *a b*.

On the fore part of the great fac, and communicating with it, a much fmaller one *e* is found, which likewife contains both cretaceous and vifcid watery matter (*g*). From this fmall fac a duct *e* is fent off, which opens into a duct *f*, common to an anterior and exterior horizontal femicircular canal *g h*, and the other two ends of thefe femicircular canals join together at *i*; and where they meet, they alfo communicate with the end of their common duct *f*. Hence the large fac *b* communicates by the medium of the fmall fac *d* with the anterior and with the horizontal femicircular canals *g h*. Thefe again communicate with each other, firft by their common duct *f*; and in the next place a duct, formed by their common duct *f* and by the duct *e* from the fmall fac, joins at *i* with the meeting of the other two ends of thefe canals, juft under the end of the meatus auditorius externus, where it opens into the large fac.

The two ends *l m* of the pofterior femicircular canal join with each other at *n*; and the upper end *l* communicates directly with the large fac at *k*.

When we review the defcription and figures, it appears, that the canals we have from analogy called *femicircular* are in the fkate circular; and that the cavities of all of them communicate, through the two facs defcribed, with the meatus auditorius externus.

In each of the femicircular canals there is a dilatation or pouch, fhaped like that part of our red veins at which valves are found; yet there are no valves in them.

The anterior and pofterior circular canals confift of an upper and under portion; between which there is a thin ligament *p p* which ferves as a fupport to them.

The large fac refembles our veftible; and the fmall fac has fome likenefs to the tube which in birds feems to fupply the place of the cochlea.

The membrane of the drum and the cavity of the tympanum are wanting; which, as the found is not conveyed by the air, we might *à priori* have fuppofed would be the cafe: and the meatus auditorius externus performs the office of the Euftachian tube; at leaft fo far as that tube may be fuppofed to ferve the purpofe of difcharging ufelefs or hurtful matter. The circular canals are filled with a vifcid liquor fimilar to that in the large fac. The membrane which compofes them is tranfparent, but thick and pretty tough; and even when diftended, they are fo much fmaller than the canals of cartilage which contain them, that between them and the cartilage there is a vifcid watery liquor contained in a cellular fubftance; on the threads of which, veffels both circulating and abforbent, and nerves, are difperfed (*h*).

Thefe facs and circular canals are furnifhed with very large nerves, derived from nerves which refemble our fifth and feventh pairs (*i*).

The anterior and horizontal circular canals are fupplied from the fifth pair; the facs and pofterior circular canal are fupplied from the fifth and feventh pairs

(*g*) In Tab. XXXVII. fig. 3. thefe facs and the femicircular canals are very accurately delineated; to which therefore this defcription chiefly refers.

(*h*) See Tab. XXXVII. fig. 4. *b c d e f*.

(*i*) Tab. XXXVII. fig. 1. and 4. 27—34. and 35. 36. 37.

pairs conjoined. After reaching the facs and canals, and running a little way upon their membranes, they lofe their white colour, become pellucid, and difappear.

§ 5. *A Defcription of the Ear of the Squalus Squatina of Linnæus.*

In the fqualus fquatina, or angel fifh, another of the flat cartilaginous fifhes, I have found the ftructure of the organ of hearing to agree fo nearly with that of the fkate, that I think it unneceffary to obferve farther, than that the external meatus auditorii are found at nearly the fame place, to wit, over the upper and pofterior part of the head near its joining with the fpine (*k*). Within the external orifice there is a winding concha K, from which a fmall cylindrical meatus L leads into a large fac or veftible M, filled with a vifcid watery humour and cretaceous foft fubftance; and with this three circular canals N O P communicate.

§ 6. *A Defcription of the Ear in fome of the long-fhaped Cartilaginous Fifhes, and in the Offeous Fifhes.*

At the lower end and pofterior part of the fides of the cranium, feparated from the brain by membranes only, we find the organ of hearing fituated in the offeous fifhes, and in fome at leaft of the oblong-fhaped cartilaginous fifhes. I have chiefly examined the cod and the fturgeon. In both, the organ confifts of three femicircular canals, to wit, an anterior and pofterior perpendicular canal, and a middle horizontal one (*l*).

Each of the perpendicular canals has a dilated portion or bulb at one of its ends, where it joins with the horizontal canal (*m*); and in the anterior of thefe in the cod, a fmall fcabrous calcareous ftone is lodged (*n*). The anterior end of the horizontal canal is likewife dilated (*o*).

The fmall upper ends of the anterior and pofterior femicircular canals join together, and form a common canal, which defcends perpendicularly (*p*).

The horizontal femicircular canal has its large end joined to the bottom of the anterior canal, and its fmall end joins with the under end of the pofterior femicircular canal (*q*).

Thefe common canals open into the under part of the perpendicular canal, and

(*k*) See Tab. XXXVIII. F G H H I.

(*l*) Tab. XXXIX. K L M N O P. and Tab. XL. fig. 3. and 4. A B C D E F G.

(*m*) See Tab. XXXIX. fig. 1. and 4. L P. and Tab. XL. fig. 3. and 4. B D.

(*n*) Tab. XXXIX. fig. 3.

(*o*) See Tab. XXXIX. fig. 1. and 4. L L. and Tab. XL. fig. 3. and 4. E E.

(*p*) See Tab. XXXIX. fig. 1. and 4. K. and Tab. XL. fig. 4. G.

(*q*) See Tab. XXXIX. fig. 1. and 4. and Tab. XL. fig. 4.

and of courfe meet there, and communicate freely with that canal and with each other (*r*).

We next find a fac of confiderable fize, in which a large fcabrous calcareous ftone is lodged (*s*). This large ftone, as well as the fmaller in the femicircular canal, feems to be furrounded by a vifcid humour.

A hole or opening in the fore or under part of the common perpendicular canal leads into this fac in the fturgeon (*t*): but I have not obferved any fuch opening in the cod or haddock.

Very large nerves are fixed to the bulbous parts of the femicircular canals; and fpreading out on thefe canals, they become fuddenly pellucid (*u*).

On the fac which contains the large ftone, efpecially of the cod, a confiderable nerve is fpread in a moft elegant manner (*x*).

The femicircular canals and large fac contain, befides the ftones, a vifcid humour; and as the femicircular canals are much fmaller than the canals of bone or cartilage which contain them, fo we find a quantity alfo of vifcid humour between their outer part and the bones or cartilages.

In the cod, haddock, and perhaps the whole genus of gadus, a number of fmall fpheroidal bodies, which I have obferved to form part of their nervous fyftem, is to be found in this vifcid humour fupported by fmall fibres of veffels and of nerves (*y*).

I have alfo in the cod obferved a bag about the fize of a pea a little farther back than the pofterior femicircular canal, filled with vifcid humour, and with a nervous filament from the nerve which fupplies the large fac; and which I fuppofe to be part of the ear (*z*).

I have not, however, been able as yet to difcover in thefe fifhes any meatus auditorius externus.

(*r*) See Tab. XXXIX. fig. 1. and 4. K. and Tab. XL. fig. 4. G.

(*s*) See Tab. XXXIX. fig. 1. and 2. Tab. XL. fig. 4. H I.

(*t*) Tab. XL. fig. 4. I.

(*u*) See Tab. XXXIX. fig. 1. and 4. Q R S.

(*x*) Tab. XXXIX. fig. 1. and 4. R R.

(*y*) See Tab. XXXIX. fig. 1. and 4. T.

(*z*) Tab. XXXIX. fig. 4. V.

CHAP.

CHAPTER IX.

EXPERIMENTS on HEARING in WATER.

AFTER defcribing the ftructure of the ear in fifhes, I fhall give an account of a few experiments I made, in 1780, on hearing in water, that we may be able to judge better of the effect of found upon the ears *.

I employed two bells, the found of which I was ufed to; one of them a fmall tea-table bell; the other much larger and thicker, fo that the found of it could be very well heard at the diftance of a quarter of a mile.

When thefe were plunged under water and rung, I obferved that the found of them was very fenfibly graver; but ftill the ringing tremor of both was very diftinguifhable. On performing an accurate experiment, the tea-table bell was found to found in air the higheft G of a common harpfichord; but in water it founded a fifth falfe lower, or it founded the C fharp under the G.

I next plunged my head under the water while I rung the bell in the air, and heard the found of it diftinctly. As the tone of the bell is louder and more acute in the air than in the water, I need fcarcely obferve that its found is better heard when the head of the perfon making the experiment is under the water and the bell above it, than when the bell is rung under the water while the head is above it.

I next plunged my whole body with the bells, holding their handles in my hands, under the water; and then rung them, and was furprifed with the loudnefs and diftinctnefs of their founds, and could readily diftinguifh their different tones.

In like manner, when, plunged under the water, I ftruck two ftones held in my hands againft each other, I was furprifed with the fhock communicated to the ears.

I

* The ingenious Abbé Nollet has, about forty years ago, publifhed an account of various experiments he made on this fubject: "Le refultat en a eté, que non feulement le bruit, quoique plus ou moins affoibli, fe tranfmettoit à travers "l'eau, mais encore l'efpece de bruit, les tons et les articulations de la voix humaine (*a*)." And the celebrated Dr B. Franklin mentions, in 1762, as his opinion (*b*), "That water will convey found farther and more readily than air; be-"caufe two ftones being ftruck fmartly together under water, the ftroke may be heard at a greater diftance by an ear pla-"ced alfo under water in the fame river than it can be heard through the air. He thinks he has heard it near a mile: "how much farther it may be heard he knows not; but fuppofes a great deal farther, becaufe the found did not feem "faint, as if at a diftance, like diftant founds through air, but fmart and ftrong, and as if prefent juft at the "ear (*b*)."

(*a*) See Hift. de l'Acad. R. des Sciences 1743, p. 26. et Mem. p. 199. &c.

(*b*) See Letters, &c. by Dr B. Franklin, L. xliv. dated July 20. 1762.

I afterwards, by means of a ſtring tied to the handle of the largeſt bell, and to an inflated bladder, ſuſpended that bell in a very deep pool, ſix feet under the ſurface of the water, and took hold of a cord twelve yards long, which I had before tied to its handle. I then plunged under the water and pulled the cord, and found that the ſound was inſtantly conveyed to my ears.

In the laſt place, I thought of trying an experiment, to determine whether air or water conveyed ſound quickeſt: but as we have no lake near Edinburgh above eight hundred feet broad, I found it impoſſible, independently of the difficulty of conſtructing a proper apparatus, to perform an experiment in a deciſive way.

It may however be worth while to mention one trial I made. I charged three Engliſh-pint bottles each with about ten ounces of gunpowder. I then inſerted a tin-tube four feet in length into each bottle, and prevented the water from getting into the bottle by wrapping a piece of wet bladder around the neck of it and the end of the tube which entered into it, and tying the tube and neck of the bottle to each other.

After filling the tube with gunpowder, I fixed to the top of it a piece of match-paper; and into the match-paper, juſt over the top of the tube, I put two ounces of gunpowder.

I then ſunk the bottle near the ſide of a lake to the depth of about two feet, and went into the water at the greateſt diſtance poſſible, which was about eight hundred feet, and laid myſelf on my back in the water, with my ears under its ſurface, and noſe and eyes alone above it. The match was then ſet fire to by another perſon; and as it was midnight, I ſaw the flaſh of the gunpowder contained within the match, and ſoon after heard the noiſe of the exploſion of the powder within the bottle. But I found it was impoſſible in this way to determine the velocity of the ſound with accuracy; for the gunpowder within the bottle was not ſet fire to through the tube ſo inſtantaneouſly as I had expected.

When the powder contained within the match-paper of the ſecond and third bottles took fire, I plunged myſelf entirely under water.

Upon the whole, beſides not being provided with a proper apparatus, and not having acceſs to a piece of water of ſufficient extent, this experiment was not repeated often enough: So that all the concluſion I could draw was, that after the bottle burſt, I heard one, but did not hear two exploſions; ſo that the water ſeemed to convey the ſound in nearly the ſame time as the atmoſphere *.

* A good method of making ſuch an experiment would be, to ſuſpend under water, in a broad lake, a very large and loud-ſounding bell, ſuch as is uſed in churh-ſteeples, and for one perſon to ſtrike this with an iron-hammer, between the handle of which and the trigger of a muſket, or cannon fitted with a lock, a rope was ſtretched; while another perſon was ſtationed at the diſtance of a mile or more, with one or both ears under the water.

By this means, as two very different ſounds would be produced at the ſame inſtant, the one in air and the other in water, it might be obſerved which of them ſtruck the ear ſooneſt. Beſides this, the flaſh ſhowing the exact time at which the bell was ſtruck, the velocity of the ſound in the water might be accurately determined.

CHAPTER X.

Of the feveral Ways in which the TREMOR of SONOROUS BODIES is communicated, in the different CLASSES of ANIMALS, to the Nerves fpread out on the Bottom of the EAR.

HAVING defcribed the ftructure of the ear in the amphibious animals and in fifhes, and that of the mammalia and birds being fuppofed to be underftood, we fhall proceed to confider the way in which the tremor excited by fonorous bodies is communicated in the different claffes of animals to the nerves fpread out on the bottom of the ear.

It is very generally fuppofed, that in the mammalia and in birds, befide the impreffion which may be communicated to the nerves of the ear by the tremor of the whole bones of the head *, a diftinct impreffion may be conveyed to them in three different ways.

In the firft place, and chiefly, by the chain of bones, cartilages, and ligaments, regulated by their mufcles, which connects the membrane of the drum to the membrane of the oval hole.

In the next place, as one fcala, or one half of our cochlea, begins at the membrane of the round hole which is not directly connected to the membrane of the drum, and as men and other animals have feemed to diftinguifh founds, with confiderable acutenefs, after the chain of fmall bones was deftroyed by difeafe or experiment, there is reafon to believe that we receive a fecond and pretty diftinct impreffion by the medium of the air contained in the cavity of the tympanum.

This air is fuppofed to be agitated, and to communicate its tremor in two different ways, to wit, by receiving motion from the membrane of the drum; and befides this, by a tremor of the external air communicated to it through the Euftachian tube, which, authors pretend, is admirably fuited to this purpofe by its fituation, fhape, and the elaftic materials of which it is compofed. Nay, the generally accurate Valfalva relates a cafe, which has been confidered as an undoubted proof that found is conveyed by this channel.

Yet

* The found of an ordinary watch applied to the fore-teeth of the upper jaw is heard diftinctly; but its found is not fo well perceived on applying it in like manner to the teeth of the under jaw: fo that the tremor feems to be conveyed to the portio mollis, not by the branches of the fifth pair of nerves, or portio dura of the feventh pair, as has been fuppofed, but by the bones of the head.

Yet the following ſimple experiment which I made twenty years ago, is ſufficient to convince us that no diſtinct impreſſion is tranſmitted through the Euſtachian tube.

I placed an alarm-clock, which rings very loud, upon one cuſhion, and I ſtood upon another. Then having ſtopped my meatus auditorii externi, I ſet the clock a-ringing, without being able to hear its ſound. In like manner, when I held my watch near to the external ear, I heard its ſound diſtinctly; but when I held it within my mouth, between my tongue and the roof of my mouth, without allowing it to touch either, and then ſtopped my external ears, I did not hear its ſtrokes.

The primary uſe, therefore, of the Euſtachian tube is to furniſh air to the cavity of the tympanum, through which the tremor of the membrane of the drum may, in the firſt place, be communicated to the membrane of the round hole: but, in the next place, as air is conveyed to the cavity of the tympanum in amphibious animals where the round hole and cochlea are wanting, we muſt ſuppoſe that the tremor of the air in the tympanum ſerves to influence the foot of the ſtapes and membrane of the oval hole; or that two different impreſſions are made on the membrane of the oval hole.

We ought farther to conſider, that in the amphibia the tremor of the chain of ſmall bones will be much leſs interrupted by air than it would have been by a watery liquor filling the cavity of the tympanum.

From the membranes of the oval and round holes the impreſſion of ſound is undoubtedly conveyed to the portio mollis by the medium of a watery liquor, which fills the cavities of the veſtible, ſemicircular canals, and cochlea, in all animals.

When we now compare the mammalia and birds with the amphibia and fiſhes, we underſtand the reaſon of ſome principal differences of ſtructure.

The whale, though he ſeems at firſt ſight amphibious, has the ſame ſtructure of heart and lungs as man; and is therefore obliged to breathe air frequently and regularly, and to live chiefly upon the ſurface of the ocean. Hence his ear is calculated to receive ſound from the air by an external meatus.

But in the amphibia, where a part only of the maſs of blood paſſes through the lungs, and which therefore poſſeſs the power of breathing arbitrarily, or of plunging under water, and ceaſing from breathing for a length of time †, the ear is conſtructed ſo as to receive the firſt impreſſion either from the air or from the water; but by means of an Euſtachian tube, air is introduced into the cavity of the tympanum when they breathe; and through it the impreſſion is conveyed from the atmoſphere, to which their ears are generally expoſed, to the bottom of the ear with more force than it would have been by the medium of a watery fluid ſecreted into the cavity of the tympanum.

In fiſhes, living in and breathing in water, not only the impreſſion of ſound on the ſurface of the ear is tranſmitted by the water, but is of neceſſity conveyed by

† I have obſerved a turtle keep under water for three quarters of an hour; and I have found that it requires five or ſix hours to drown a frog.

by the ſame medium to the bottom of the ear. Hence it is evident they have no occaſion for a cavity of the tympanum nor for an Euſtachian tube.

At the bottom of the ear we find in all fiſhes ſemicircular canals, ſimilar in ſhape and ſituation to thoſe found in the mammalia, but much larger and more extenſive in their ſurface; in order, perhaps, to compenſate for the leſs forcible impreſſion made by the water in them than in us by the air.

Connected with the ſemicircular canals, we find ſacs containing cretaceous matter, which perhaps we may think have as much reſemblance to the cochlea as to the veſtible in our ear, if we reflect that in birds the place of the cochlea is ſupplied by a ſhort ſtreight tube.

The cretaceous matter, which in the piſces of Linnæus, and ſome of his nantes pinnati, forms hard and rugged ſtones, may ſerve, like the ſmall hard bones of our ear, to convey a more forcible impreſſion to the nerves ſpread out on the membranes which contain them.

Several of the cartilaginous fiſhes, the raja, ſqualus, &c. have a meatus auditorius externus, through which the ſound is conveyed by a watery viſcid liquor to the inner ſides of the membranes of the ſemicircular canals and ſac or ſacs containing the cretaceous matter: but in the piſces of Linnæus, and in ſome of his nantes pinnati, as the ſturgeon, I have not yet found a meatus auditorius externus; and as I farther obſerve, that the common canal or veſtible, where the three ſemicircular canals communicate, is ſeparated from the cavity of the cranium by a thin membrane only; and that this cavity, in by far the greater number of fiſhes, contains a watery liquor in conſiderable quantity; and that, from the thinneſs of the cranium, the tremor excited by a ſonorous body may be as readily tranſmitted through their cranium to the water within it, and ſo to the ear, as through the temple of the turtle to his ear; I am more inclined to ſuppoſe, that in them there is no meatus auditorius externus, than that, from the want of ſufficiently accurate inveſtigation, it has not as yet been diſcovered.

CHAP.

CHAPTER XI.

Of the EYES in FISHES.

IN treating this fubject, I fhall firft make fome curfory obfervations on the coats, and afterwards confider the humours of the eye, their texture, fpecific weight, fhape, and powers of refraction.

In fifhes, birds, and in all animals in which objects often imprefs one eye folely or chiefly, the optic nerve is, as *à priori* we might have fuppofed, much more eccentrick than in man.

I have in a former work obferved (*a*), that the retina terminates in man near to the roots of the ciliary proceffes; which circumftance is equally obfervable in fifhes.

In all fifhes, fo far as I have obferved, the pigment on the inner fide of the choroid coat is, as in land-animals which feek their food in the night-time, of a bright colour at the bottom of the eye; perhaps becaufe the light ftrikes the bottom of their eye with lefs force than in the land-animals, many of its rays being intercepted by the water. To account, however, for the diverfity of the colour of this pigment, or tapetum as it has been called, in the different genera of animals, feems to be a matter of much difficulty. Nay, it may be a queftion, whether the chief ufes of the choroid coat in any animal have been clearly afcertained; or whether we certainly know in what manner the choroid coat is fubfervient to the retina. Perhaps attention to the powers of the eye in two animals which are mere varieties of the fame fpecies, may ferve to throw farther light on this curious fubject; I mean the brown and the white rabbit: for in the former, the choroid is every where covered with a dark pigment; whereas in the latter, although the choroid coat is as much compofed of veffels as in other animals, I have found that the black paint, tapetum, or inner layer of the choroid, is altogether wanting: And hence the colour of the red blood circulating in the veffels of the choroid is feen when we look into the eye, or makes their eyes appear red †.

(*a*) On the Nervous Syftem, chap. xxi.

† In juftice to an ingenious and diligent ftudent of phyfic, Mr William Rofs, I think it proper to obferve, that I was led to examine this curious circumftance by a letter I received from him in fpring 1781; in which he alledged that the choroid coat was altogether wanting in the white rabbit. In a fecond letter, above fix months thereafter, he retracted as an error what he had wrote to me. In the mean time I had found, that although they have the choroid coat, the pigment is wanting. It would be worth while to examine the choroid coat in the mixed breed between the brown and white rabbit.

The iris, though not the continuation of the choroid coat, refembles it in being covered on its inner or back part by a dark pigment; but it has the addition of a coloured matter laid over its fore part; and thefe concealing its veffels and their contents in a living animal, feveral eminent authors, whom Dr Haller follows, have entertained the erroneous idea, that the arteries of the iris in man and quadrupeds do not in life convey the red part of the blood, but the lymph alone; and that they are colourlefs or lymphatic (*b*). Yet thofe very authors admit, that the arteries of the iris may be filled with an injection coloured with the powder of vermilion; and Dr Haller in particular has delineated the large branches of thofe arteries in a very juft and elegant manner as they appear to the naked eye (*c*). By what power or mechanifm, then, could he, Mr Ferrein, and others, conceive the red blood to be excluded in life?

The plain facts here are, as I have repeatedly obferved, 1*ft*, That by a fkilful injection the whole iris, to the very edge of the pupil, may be made nearly as red as a piece of fcarlet cloth. 2*dly*, That the whole courfe of the blood, from the trunk of the ocular artery to the arteries of the iris, may be traced with the naked eye. 3*dly*, That if any part of the iris be cut or punctured in a man, which I have feen happen in the attempt of extracting the cryftalline lens, red blood immediately flows from its veffels. Nay, in one fuch cafe, a red-coloured fungus, rooted in the iris, afterwards pufhed out at the wound in the cornea.

In one kind of fifh, the fkate, the upper part of the iris in the horizontal pofture is formed into a beautiful palmated procefs (*d*); which it is probable the animal has the power of elevating and depreffing according to the quantity of light; and perhaps he lets fall this curtain in time of fleep. It may likewife be worth while to obferve, whether the mind of the animal, independent of the degree of light, poffeffes fuch a power over it as I have very long ago obferved to be exercifed by the parrot; which, in an obfcure light, opens and fhuts the pupil alternately when agitated by paffion.

In man, the cornea is, beyond doubt, covered with the continuation of the fkin; which in the found ftate poffeffes a confiderable degree of fenfibility, and, when irritated by extraneous fubftances fticking in it, occafions, as I have feveral times feen, violent inflammation of the whole eye; in confequence of which, fpecks, full of veffels containing red blood, are often produced upon the cornea: and, what is remarkable, and ufeful to be attended to by the oculift, thefe veffels, from whatever caufe produced, are, fo far as I have obferved, not the original veffels of the cornea running between its layers, dilated by the inflammation, but are new veffels growing from the veffels of the tunica adnata, and extended over the external furface of the cornea. Hence we perceive the propriety of attempting to remove thefe by operation and external applications (*e*).

The

(*b*) Ruyfch, Vieuffens, Ferrein, Mem. de l'Ac. 1739. Haller, Phyf. t. v. p. 439.

(*c*) Haller, Fafcicul VII. Tab. VI. fig. 4. 5. 6.

(*d*) See Tab. VII. fig. 3. 22.

(*e*) Dr Haller, El. Phyf. L. xvi.. p. 362. unjuftly denies the fenfibility of the cornea: "Neque fenfus figna aut homo edit, aut "animal," &c.

The inner part of the cornea feems to be lined with a thin very denfe membrane, fit for confining the aqueous humour. But in man and quadrupeds it is very difficult to feparate thefe coats of the cornea from each other; whereas in fifhes they may be feparated with the utmoft eafe.

The humours of the eyes of fifhes are proportionally in greater quantity, or much larger, than thofe of animals living in air. Thus the eye of the cod is very nearly of the fame weight and depth, and its axis of the fame length (*f*), as the eye of the ox. On this account I have, in the following experiments, made chiefly the comparifon of thofe with each other.

As the rays of light fuffer great refraction in paffing from the rare medium of air into water, the cornea of land-animals is very convex. From this they poffefs alfo two other advantages; that a fmall motion of their iris excludes the fuperfluous quantity of light; and that their cryftalline lens needs not be very convex, and may therefore be placed at a diftance from danger.

But as there is little or perhaps no refraction of the light paffing from falt-water into the aqueous humour of the eyes of fifhes, their cornea has little convexity, and perhaps would have been altogether flat, but that a quantity of aqueous humour is neceffary for giving room and protection to their very convex cryftalline lens, and for allowing the motion of the iris. Nay, in one animal, which makes the neareft approach to this clafs of animals, the fepia loligo, I have found the cryftalline lens attached to the cornea, and the aqueous humour and iris altogether wanting (*g*).

The cryftalline lens is known to be compofed of concentric layers, and thefe of fibres; and the central part being harder than the furface of the lens, has been called its nucleus. But it may be obferved, that the hardnefs does not increafe from the furface to the centre in a perfectly equable manner; but that, at the depth of one third nearly of the diftance of the furface from the centre, there is a fudden increafe of the hardnefs of the lens: So that if the capfule of the lens be feparated from a number of lenfes of the fame kind of animal, and the lenfes rolled between the thumb and fingers in a bafon-full of water, with the view of detaching the foft fuperficial parts, the nuclei of all the lenfes will remain nearly of one fize; and their diameter will be to the diameter of the entire lens nearly as two to three.

After repeatedly comparing together the fpecific gravity of the aqueous, the cryftalline, and vitreous humours of the ox and cod, by weighing them in air and water, I found their proportional weight to be as follows:

	Parts.
Spring-water, ...	1000
Aqueous humour, ...	1000
The vitreous humour of the ox, . . .	1016
The vitreous humour of the cod, . . .	1013

The

(*f*) Dr Porterfield, and others, miftake in fuppofing the eyes of fifhes to be flatter behind, as well as before, than the eyes of land-animals.—Porterfield, v. ii. p. 262.

(*g*) See Tab. XLI. fig. 3. *t. u.*

	Parts.
The whole cryſtalline lens of the ox,	1104
The whole cryſtalline lens of the cod,	1165
The outer part of the cryſtalline lens of the ox,	1070
The outer part of the cryſtalline lens of the cod,	1140
The nucleus of the cryſtalline lens of the ox,	1160
The nucleus of the cryſtalline lens of the cod,	1200

On comparing the cryſtalline lens of the ox with that of the cod, I found that they were very nearly of the ſhape delineated in Table XL*. fig. 1. where the outermoſt dotted lines repreſent an horizontal ſection of the lens of the ox, and the continued lines the ſame of the cod: and they meaſured one-fourth part of the diameter repreſented; or one-tenth of an inch in this figure repreſents one-fortieth of an inch in their cryſtallines: Or I found the radii of the ſpheres which compoſe the lens in theſe two animals to be in fortieths of an inch nearly as in the following table.

The radius of the anterior part of the lens of the ox,	21
The radius of the anterior part of the lens of the cod,	14
The radius of the poſterior part of the lens of the ox,	15
The radius of the poſterior part of the cod, which is nearly an hemiſphere †,	$13\frac{11}{21}$

In the laſt place, I found that the focus of the rays of the ſun, which was nearly $\frac{1}{40}$th part of an inch in diameter, was diſtant from their poſterior part,

In the ox, $\frac{13}{40}$ of an inch;

But in the cod, not more than $\frac{3}{40}$.

And I obſerved that the diſtance of the focus from the ſurface of the whole lens, or from that of the nucleus in the cod, was nearly the ſame.

The focus of the nucleus of the lens of the cod placed in water was about $\frac{16}{40}$ of an inch diſtant from its back part.

Hence it is evident, that the cryſtalline lens of the cod, but eſpecially its nucleus, is much more denſe, and refracts light more readily, than that of the ox: nay, that its refraction, inſtead of bearing proportion merely to its ſpecific weight, with ſome little addition on account of its containing inflammable matter, which is the common ſuppoſition ‡, is more powerful than that of common

† The celebrated Dr Petit has, in the Mem. de l'Acad. 1730, p. 9. deſcribed the breadth and thickneſs of the cryſtalline lens, particularly of the ox, and the radii of the ſpheres which compoſe it, with ſo much appearance of accuracy, that his deſcriptions have been univerſally received by authors: Yet I have not only obſerved by meaſuring, that the lens of the ox is much more convex on both ſides than he repreſents it; but it will be found impoſſible, with ſuch radii, to deſcribe a lens of the breadth and thickneſs he himſelf aſſigns to it. When we aſſume his radii and breadth, a much flatter lens than that of the ox is produced; and which the innermoſt dotted lines I k L m repreſent in Tab. XL*. fig. 1.

Nay, it is demonſtrable, that he has erred greatly in every example in his Table of the human lens, as well as in that of the lens of the ox, his radii not correſponding, in a ſingle inſtance, with the breadth and thickneſs of the lens he found by meaſurement.

‡ Dr Porterfield, v. i. p. 232. § 9. p. 278. &c. Pemberton. Haller, El. Ph. l. 16. p. 402. Neque vitri habebit vim refractilem..... Parvam eſſe qua aquam ſuperat prærogativam nuperi fatentur.

common glaſs: for the nucleus of the lens of the cod, which is nearly ſpherical, forms its focus at the diſtance of a little more than one-ſixth part of its diameter; whereas parallel rays of light, paſſing from air through a ſphere of glaſs, are not collected into a focus till they are one-fourth of its diameter diſtant from its poſterior part.

The lateſt and moſt eminent writers on the eye have taught, that a principal uſe of the ſpherical figure of the cryſtalline humour of fiſhes, is to enable it to collect the rays of light more powerfully, or nearer to the fore part of the eye, than could be done by a lens compoſed of two ſmall portions of a ſphere †.

But on caſting the eye on Table XL*, fig. 2. it appears, that the focus of a ſphere is nearly, but not exactly, for the proportion varies according to the medium, as much more diſtant from its anterior part, than the focus of a lens compoſed of two portions of the ſame ſphere, by as much as the thickneſs or diameter of the ſphere is longer than the thickneſs or axis of the lens.

Nay, from the ſame figure it is evident, that a lens, the axis or thickneſs of which is equal to the radius, and its breadth equal to the diameter of the ſphere, and compoſed therefore of two portions of a larger ſphere, has its focus conſiderably nearer to its fore part than the ſphere has.

Upon the whole, therefore, we are led to the concluſion, That the primary uſe of the almoſt completely ſpherical figure of the cryſtalline lens of fiſhes, or great convexity eſpecially of the anterior part of their lens, which I find projects in the cod about ſeven fortieths of an inch beyond the iris, is to take in a large field of the objects around them; which was particularly neceſſary, as the motion of their neck is inconſiderable.

To enable them, with the ſame length of the axis of the eye as in the quadruped, to collect into a focus on the retina the rays of light coming from the denſe medium of water, four chief circumſtances concur.

In the firſt place, We obſerve that their cryſtalline lens is more convex, or compoſed of portions of ſmaller ſpheres, than in land-animals.

In the next place, We have found that their cryſtalline lens is, in correſponding parts, much more denſe than in animals which live in air.

Thirdly, That the lens in fiſhes poſſeſſes powers of refracting light far beyond what have been calculated by authors, who have proceeded on the ſuppoſition that theſe powers were proportioned nearly to its ſpecific gravity.

In the laſt place, The vitreous humour of fiſhes being lighter than that of land-animals, the rays of light iſſuing from their lens will be refracted in a greater degree, or brought ſooner to a focus ‡.

† Dr Porterfield on the Eyes, v. ii. p. 261, 262. Dr Haller, El. Phyſ. L. xvi. p. 468. Hinc piſcibus, quorum radii minus refringuntur, lens pene ſphærica.

‡ Dr Haller, on this ſubject, Pr. Lin. Phyſ. DXXXVIII. and in Elem. Phyſ. t. v. p. 467. commits the overſight of ſuppoſing, that becauſe the vitreous humour is more rare than the cryſtalline lens, it will have the effect of making the rays longer of coming to a focus; whereas the leſs its denſity is ſuppoſed in proportion to that of the lens, the more the rays will be refracted and the diſtance of the focus leſſened. Hence the vitreous humour is made viſcid and heavy, merely becauſe a cuſhion for ſupporting the lens at a proper diſtance from the retina was neceſſary.

I cannot conclude without obferving the probability, that attention to the denfity, fhape, refracting powers, and connection of the humours of the eyes of animals, may lead to the ftill farther improvement of optical inftruments.

CHAPTER XII.

Anatomy of the Sepia Loligo.

TO this account of the ftructure of fifhes, I fhall fubjoin a defcription of that of the Sepia Loligo; which I have found not lefs remarkable in its internal ftructure than in its external fhape. By moft authors it has been ranked among the fifhes; by Linnæus it has been placed among the worms; but perhaps it may moft juftly be confidered as a link connecting thefe two claffes of animals.

The fepia loligo, which wants fins, has a triangular-fhaped tail (fee Tab. XLI. fig. 1. A A), and a hollow conical-fhaped mufcular fheath, which inclofes its thoracic and abdominal vifcera; reaching from its throat, where it is open and admits the fea-water freely, to its tail, where it is fhut. This fheath cut open is reprefented at B B.

Near the mouth of the great fheath there is another flefhy conical funnel C, wide behind and narrow before.

The fepia I laft diffected had ten arms D D D, &c. with a great number of cups E E E on each; by means of which it fixes itfelf to a rock; and with a beak F, like that of a parrot, it breaks the fhells of the fea-worms on which it feeds.

From the mouth the œfophagus G G fig. 3. runs ftraight down, covered behind by its principal bone, or os fepiæ, to end in a very mufcular ftomach H, fig. 1. fituated near the tail.

From the fore part of the ftomach, very near its cardia, the inteftinal canal, I, begins; and after making a very few turns, ends in the rectum KK, which runs ftraight upwards on the fore part of the liver, and opens about the root of the flefhy funnel C.

The liver M M is of great fize, and is fituated lengthwife on the fore fide of the œfophagus.

On the fore fide of the liver, between it and the rectum, the ink-bag N is fituated, tied to both. This bag is of a conical fhape, and of confiderable fize. The

The duct from it, O, runs upwards between the liver and rectum, parallel with the rectum; into which, very near the anus, it difcharges itfelf.

As I did not obferve any other bladder connected with the liver, I fuppofe that the ink is the gall of this animal; yet while I was detaching the ink-bag and its duct from the liver, I did not obferve that any gall-ducts were cut, nor could I perceive, on fqueezing the liver or ink-bag, that any gall or ink was effufed. Still, however, confidering the fituation and connection of the ink-bag, this is perhaps not an improbable conjecture. If fo, we are led a ftep farther; I mean, that as in this animal the bile does not ferve any of the purpofes commonly affigned to it, but is thrown out merely to affift the animal in making its efcape, there is fome reafon to fufpect, that one principal ufe of the liver may be to drain off from the conftitution fome matter that is hurtful to it, or that the bile is an excrementitious liquor.

Notwithftanding the great fize of the liver, I did not obferve any organ analogous to the fpleen.

When we review the parts that have been defcribed, it feems propable that the animal may pufh its body forwards by the motion of its tail. But if the tail is at reft, and the large outer fheath ftrongly and fuddenly contracted, the reaction of the water within the fheath will throw the whole body of the animal backwards, whilft, at the fame inftant, the ink will be thrown out of the bag, and perhaps directed and thrown with ftill greater force by the action of the mufcular funnel C.

If the tail be directed upwards, it is plain that the animal may, by fuch an exertion, jump upwards out of the water, and ftill more readily make an efcape from its enemy.

Between the abdominal bowels and the back-bone I obferved a large thin-coated bag P, which in the firft fepia I examined was empty, and feemed to refemble the fwimming-bladder of fifhes: but in others I diffected afterward, I found it filled with a watery liquor, and a paffage or duct into it from a glandular-looking organ; from which I fuppofe it to be the bladder of urine (*h*).

On the under fore part of the liver and ink-bag, I remarked a glandular-looking organ LL, confifting of a number of minute lobes; which I fufpected to be the ovarium of this animal.

In another larger fepia, I found a confiderable fac, with a large and long duct from it, which terminated near the anus; and from which, on a flight preffure of the fac, vermiform bodies were difcharged (*i*). Whether thefe are portions of the organs of generation, which, after fome degree of putrefaction, were detached in this tender animal by flight preffure; or whether thefe bodies are naturally difcharged in the production of the young, future obfervation muft determine.

The gills or lungs of this animal are two conical-fhaped bodies QQ; one fixed

(*h*) See Tab. XLII. PQRS.

(*i*) See Tab. XLII. MNO, and two figures at the fide of the Table.

fixed on each fide to the inner part of the loofe mufcular fheath, between it and the abdominal bowels.

Each of thefe gills is provided with a heart for driving the blood through it; in confequence, perhaps, of the diftance from each other at which the gills are placed. Another fingularity occurs, that the branchial or pulmonary veins, or veins returning the blood from the gills, inftead of joining together to form the aorta, as in fifhes, run into different fides of a mufcular fac or ventricle, fhaped like an egg; from the two ends of which the aortæ are fent out.

Hence there are in this animal three hearts or organs for reftoring momentum to the blood: of which, with their veffels, I fhall now give a more particular defcription, beginning with the venæ cavæ.

The anterior vena cava (*k*), R, is placed under the liver, contiguous to the rectum; and receives branches from the arms and the head S, the liver T, the ovarium, the ftomach, inteftines, and from fome fhare of the upper and back part of the body V V.

Near to the back part of the liver, the anterior vena cava divides into two equal branches W W, which meet with two large veins X X from the under and pofterior part of the animal, and which are analogous to the pofterior venæ cavæ of fifhes. The cavæ, where they meet, have a degree of reticular work, or corneæ columnæ et foveæ, on their inner fide; and from their meeting, facs Y Y, of the fame fize and fhape on right and left fides, are produced; or on each fide an oblong bag is formed, analogous to our right auricle; and both bags are inclofed in one large membranous fac or pericardium. To each of the auricles a ventricle ZZ is connected, of the ordinary conical fhape, and inclofed in its proper membranous bag or pericardium.

From each ventricle an artery *a a a a* is fent out to the correfponding gill.

When the ventricle of the heart and this artery are cut open, the communication between the auricle and ventricle is found to be of a round fhape, fig. 2. *b*; and a rifing flefhy edge *e*, on the outer fide of it between it and the artery, feems to ferve the office of a valve.

At the beginning of the artery *a* three valves *d* are formed, refembling the valves in fifhes.

The artery of the gill, or pulmonary artery *a a*, fig. 1. is remarkably large in proportion to its correfponding vein *e e*.

The pulmonary veins terminate near the middle of a thick flefhy fac *g*, which produces a conical end both on the fore and back parts, or refembles two cones joined together by their bafes. From the fore end of this conical ventricle a large artery *h* is produced, which may be called the anterior or afcending aorta.

The artery from the back end of the ventricle or pofterior aorta *i*, is confiderably fmaller than the anterior.

When this ventricle and thefe two arteries are flit open (fee fig. 2.), a pair of mem-

(*k*) See Table XLI.

membranous valves, like thofe at the termination of our thoracic duct, are found at the termination of each of the veins of the gills *k k*.

At the beginning of both aortæ there are membranous valves *l l*.

The anterior aorta fupplies the arms, the head, the liver, the mufcles above the back-bone *m*, the alimentary canal (fee fig. 1. *n*), and the organs of urine and generation.

The pofterior aorta gives fmall branches to the two pulmonary hearts *o o*, and to the ink-bag *p*, and then runs towards the tail and under part of the outer mufcular fheath *q*, fupported by a double membrane *r*, which fixes the abdominal vifcera to that fheath.

From all the branches of the aorta the blood returns directly by the two venæ cavæ to the pulmonary hearts; for there is no vena portarum as in fifhes.

The eyes (fee fig. 3. 1, 1,) are very large, and have broad eye-lids. The vitreous humour has the ufual appearance: but the cryftalline *t* is inclofed behind in a fofter fubftance or coat *u;* and before is glued by a hard plate to the cornea, without the intervention of the iris or aqueous humour. So that the cryftalline lens confifts of three different parts or pieces.

Between the eyes a foft fubftance is found, which I fuppofe to be the brain *v*, and which is placed immediately above the œfophagus G G. To it two large lobes *x x*, fomewhat firmer than the middle part, are clofely connected, whether cerebral or mufcular parts I am uncertain; and from or through them the optic nerves *y y* run to the bottom of the eye.

The middle part of the brain is connected by crura to two lobes *z z*, placed lower and farther back, which feem to be analogous to our cerebellum. The left lobe is left bare at *z*.

From the latter a white thread, larger than a briftle, runs backwards, which has fome diftant refemblance to the fpinal marrow; but from the fmallnefs of it, there is a difficulty in determining its nature with certainty or much probability.

Near to the fubftance which I fuppofe to be the brain, I found a fmall ftone which refembles the ftone in the ear of fifhes(*k*); but I have not lately met with one of thefe animals in order to profecute this obfervation.

(*k*) Tab. XLII.

CHAPTER XIII.

ANATOMY of the ECHINUS MARINUS.

IN treating of the abſorbent veſſels of the ſkate fiſh, I obſerved that the firſt origin, by open mouths, of ſome of its cutaneous abſorbents, could be demonſtrated by injecting liquors from the trunks into the ſmaller branches of certain lymphatic veſſels; and I mentioned abſorbent veſſels proper to one of the claſs of worms, to wit, the Sea-egg or Echinus eſculentus of Linnæus, G. 299. S. 1. which I had diſcovered and read an account of to the Philoſophical Society of this place in Auguſt 1761. I ſhall therefore add, as an Appendix to this work, the deſcription of this very curious animal.

I was led to examine the ſtructure of it, by having been appointed by the Philoſophical Society of Edinburgh to report to them my opinion of a paper on the ſubject, which had been preſented to the Society in November 1760 by the late ingenious Dr Thomas Simſon ſenior of St Andrew's.

The Doctor, in his paper, which was afterwards withdrawn, dwelt chiefly on the want of brain in this animal; from which he thought additional force was given to the doctrines he had publiſhed in his Eſſays on the Vital and Involuntary Motions.

I entitled my Paper, Further OBSERVATIONS on the SEA-EGG or ECHINUS.

Since that time, I have traced with greater accuracy ſome particulars in the ſtructure of its parts; which, though few in number, are ſo ſingular and remarkable, that the knowledge of them ſerves to enlarge our views in intereſting points of phyſiology.

THE ſhell of the Echinus is covered with a ſkin, and has many thouſand thorns articulated with it by means of muſcular ligaments (*l*): Hence the thorns ſerve in place of feet; and are ſo tenacious of their powers, that I have ſeen the pieces of a broken ſhell walk off in different directions. Yet there is no appearance of any organ like to the brain.

It does not, however, follow that they are deſtitute of nerves; ſince theſe may exiſt independent of the brain, and be ſo ſmall as to eſcape obſervation.

In the interſtices of the thorns there are three kinds of bodies, ſoft at the ends, ſupported on calcareous ſtalks incloſed in a membrane, and articulated with

(*l*) See Tab. XLIII. and Tab. XLIV. fig. 3.

with the ſhell by means of muſcular membranes. Not only the roots but the points of theſe bodies, which are ſhorter than the thorns, are in continual motion, poſſeſſing the powers of opening and ſhutting like the fingers of our hand, and having theſe points ſupported by a mixture of cretaceous particles with muſcular ſubſtance (*m*).

Theſe bodies ſomewhat reſemble the antennæ of inſects, and probably ſupply the place of the organs of the ſenſes in the more perfect animals.

The mouth is furniſhed with five teeth, with large ſockets (*n*), which are tied to the ſhell by a very ſtrong membrane; around which there is placed, on the inner ſide of the ſhell, an irregular ſtrong circle of cretaceous matter, from which a pair of muſcles is extended to each tooth, and other muſcles join the ſockets of the teeth to each other (*o*).

The œſophagus (*p*), after running about three inches in length, and being tied by a ligament to the ſide of the anus, makes a turn, and ſoon opens into a wider canal or inteſtine, nearly in the way our ilium opens into the ſide of the colon; and this inteſtine, after deſcribing two waving circles around the ſhell, deſcends to the anus (*q*).

On the under edge, of the whole length of the meſentery, I found two veſſels without valves, nearly equal in ſize and parallel to each other, which I injected with quickſilver (*r*); and from them filled a beautiful net-work of veſſels, not only on the inteſtines (*s*), but diſperſed on fine membranes, which tie the inteſtine to the inner ſide of the ſhell.

I could not, however, obſerve that theſe two veſſels communicated with each other directly, nor by the medium of any organ like to our heart; nor could I obſerve in the living animal any beating organ like to the heart: yet near to the anus, and connected to the rectum, which is the place of the heart in many other worms, I found a ſmall organ W, Tab. XLIII. fig. 2. which ſeems to be hollow.

It appears highly probable, that one of theſe veſſels is the principal artery or aorta, and the other analogous to our vena cava; and that they communicate by inviſible branches, and circulate the blood by the muſcular action of their coats, without the intervention of a heart, nearly in the way the veſſels in fiſhes carry the blood from the gills back to their heart.

In what manner the chylous or lacteal veins communicate with theſe two veſſels, I have not yet been able to diſcover.

In ſome animals, as in the human tænia, or faſciola hepatica in ſheep, the œſophagus, I have obſerved, may be conſidered as the aorta, conveying the chyle or bile directly to all the parts of their bodies: but here it is probable the lacteals

(*m*) Tab. XLIV. fig. 18. 19. 20. 21.

(*n*) See Tab. XLIV. fig. 3. fig. 16. 17.

(*o*) See Tab. XLIII. fig. 1. D. E. Tab. XLIV. fig. 13. 17.

(*p*) Tab. XLIV. fig. 17.

(*q*) See Tab. XLIII. F G H I K L M N O P Q, and Tab. XLIV. G K L Q.

(*r*) See Tab. XLIII. fig. 1. K L M N O P Q.

(*s*) Tab. XLIII. M.

lacteals pour the chyle into that veſſel in the meſentery which is the largeſt, and reſembles our vena cava.

A large roe, which almoſt ſurrounds the rectum, and is divided into five lobes, diſcharges itſelf by as many ducts, which pierce the ſhell near to the anus, after communicating with each other (*t*).

The roe, with the inteſtinal tube, are the chief parts which preſent within the ſhell; and to which that part of the ſtructure, which is by far the moſt intereſting to the phyſiologiſt, and which I am about to deſcribe, may be conſidered as ſubſervient.

Between the inner ſide of the ſhell and the parts I have been deſcribing, to wit, the inteſtinal tube and the roe, a large quantity of a watery liquor is lodged, which taſtes like ſea-water, and contains a thirty-ſecond part of its weight of ſaline matter; which, chemically examined, was found to conſiſt chiefly of common or ſea ſalt, but with all the other principles which ſea-water contains.

This watery liquor is ſecreted from the ſea-water by means of the following very beautiful ſtructure.

The ſhell of the echinus is pierced with upwards of four thouſand holes, diſpoſed in five pairs of rows or phalanges, which extend from near the outer ſides of the teeth to near the anus.

The holes are diſpoſed on the outer ſide of the ſhell in pairs (*u*); and with each pair an abſorbent veſſel correſponds (*x*).

This abſorbent veſſel, in its collapſed ſtate after the death of the animal, is upwards of half an inch in length. Its end is covered by a flat plate; in the middle of which is a hole, viſible to the naked eye, being about one hundred and twentieth part of an inch in diameter, and very like one of our puncta lachrymalia.

From the outer edge of this plate a number of teeth project, like the teeth on the wheel of a watch.

The flat plate is very tough; contains ſome cretaceous particles; and, when preſſed between the fore teeth, feels almoſt like a plate of talc. It ſeems to conſiſt of a number of pieces joined together; which are broader near its outer edge than at the hole in its centre (*y*).

The duct from this plate to the ſhell is compoſed of pale-coloured circular or tranſverſe fibres in faſciculi or bundles (*y*); and two ſmall bands of ſuch pale-coloured longitudinal fibres are obſervable on oppoſite ſides of the tube (*z*): or its ſtructure reſembles our colon with the muſcular bands called its ligaments.

Theſe fibres, which have the appearance and the action, as we ſhall find, of muſcular fibres, are lined with a membrane.

When we trace the two holes which pierce the ſhell, we find they diverge to

(*t*) See Tab. XLIII. fig. 2. XYZ.

(*u*) Tab. XLIV. fig. 1. 2.

(*x*) See Tab. XLIV. fig. 3. and 5.

(*y*) See Tab. XLIV. fig. 6. 7. 8.

(*z*) Tab. XLIV. fig. 11. and 12.

to oppofite fides of the row or phalanx of holes (*a*), and lead to leaves of doubled membranes, not unlike the proceffes or fubdivifions of the gills of a fkate (*b*).

When I injected quickfilver into the mouths of the external abforbent veffels, I found that it filled and diftended completely the internal leaves or doubled membranes (*c*).

When, after this injection, I applied a common magnifying glafs, I could diftinctly obferve the ducts by which the quickfilver entered the doubled membrane: nay, I could trace a plexus of communicating branches formed upon it, furrounded by a circular veffel, from which the quickfilver was conveyed by a fingle tube into a large pipe, nearly one-twentieth part of an inch in diameter; and which ferves as a trunk, receiving the fluid from one of the pairs of rows or phalanges (*d*).

Each leaf or doubled membrane receives at leaft two branches from different external abforbents. Hence we fee the reafon why each external abforbent divides into two diverging branches; that although an accident fhould deftroy one of the external tubes, the internal membrane may not be without its fupply of liquor.

The trunk laft defcribed, and there are five fuch (*e*), divides into two branches, which terminate in large facs or receptacles (*f*), over the fockets of the teeth, communicating with each other: and from thefe the liquor paffes down the fockets of the teeth, and is difcharged into the fea, on each fide of the tooth, between the focket of the tooth and beginning of the œfophagus (*g*).

The external abforbent veffel has not only the appearance of being mufcular, but contracts fuddenly when touched with fea-falt; and, like an earth-worm, or the probofcis of an elephant, it poffeffes motion in all directions (*h*); and particularly the animal poffeffes the power of ftretching it to the length of an inch and a half, and upwards.

When it is elongated, it becomes much fmaller; and the plate at its end, which, as I have obferved, appears flat after death, is pufhed out into a conical form, and the hole in its centre becomes much fmaller (*i*).

The internal double membrane, with its vafcular plexus, is likewife evidently mufcular, altering its fhape and fituation when it is touched rudely with a knife or probe, or when fea-falt is fprinkled on it.

There are no valves within thefe veffels: for, from the internal trunks, the plexus upon the doubled membranes, and the external abforbents, may be filled with injection; or when, after death, the teeth with their fockets are preffed inwards, the watery liquor contained in the internal ducts paffes outwards through the fhell, and fills the external veffels.

S No

(*a*) See Tab. XLIV. fig. 1. 2. 5.

(*b*) Tab. XLIV. fig. 13. D E.

(*c*) See Tab. XLIV. fig. 13. D E.

(*d*) Tab. XLIV. fig. 13. D E F, fig. 14. fig. 15.

(*e*) See Tab. XLIII. fig. 1. and 2. R S T U V.

(*f*) Tab. XLIV. G G G G.

(*g*) See Tab. XLIV. fig. 17. E E.

(*h*) Tab. XLIV. fig. 9. 10. 11. 12.

(*i*) See Tab. XLIV. fig. 11. and 12.

No communication of the internal ducts and plexus with the cavity within the ſhell is diſcoverable by the injection of quickſilver.

On reviewing the ſtructure of theſe ducts, there can be no doubt that the ſea-water is abſorbed by the external open-mouthed veſſels, and conveyed from them through the ſhell into the plexus of the internal doubled membranes: from which a ſecretion of part of it is made by inviſible veſſels into the cavity of the ſhell, while the remainder of the ſea-water paſſes from theſe plexus into the five large internal ducts; and from them through the receptacles at the roots of the ſockets of the teeth, to be diſcharged into the ſea by ten apertures at the ſides of the teeth.

We muſt likewiſe ſuppoſe that there is a conſtant change of the water within the ſhell; and that there are therefore abſorbing veſſels which correſpond with the ſecerning. Theſe are inviſible; and whether they terminate in the plexus and five inner ducts, or with the lacteals in the circulating ſyſtem of the animal, may perhaps be a queſtion.

No other individual of the animal kingdom ſeems to afford ſuch an opportunity of inveſtigating the ſtructure of an abſorbent veſſel, and of obſerving how it performs its office.

When the external abſorbent is elongated by the action of its muſcular fibres, it becomes ſmaller in proportion to its elongation; and it likewiſe acquires a tenſion or degree of rigidity. The jointed plate which covers its beginning, is at the ſame time thruſt out into a conical form; and the diameter of the hole or perforation in its middle, inſtead of becoming larger, is ſo very much diminiſhed, as ſcarcely to be diſtinguiſhable with a magnifying glaſs of two inches focus.

While the tube is elongated, and while the plate at its end preſerves its conical figure, I have never been able to obſerve any motion of the ſides of the hole reſembling the motion of the lips or mouth of an animal.

As the tubes are thick coated, and the ſea-water has little colour, I could not perceive it entering the tubes, or moving within them, ſo as to be able, from ocular obſervation, to determine the motions the tubes perform at the time they abſorb.

In a few experiments, I coloured the ſea-water with milk, with indigo, and with madder; but have not yet ſeen theſe colours enter the abſorbents. I am, however, far from deſpairing of ſucceſs in ſuch experiments.

Upon the whole, There ſeems to be little or no reaſon for ſuppoſing, that the ſides of the hole in the plate, at the origin of the abſorbent tubes, open and ſhut the orifice alternately; or that ſuch a motion takes place at our puncta lachrymalia, or at the mouths of the abſorbent lymphatic veſſels I have deſcribed on the ſkin of the ſkate; or that the reception of liquors into theſe veſſels, or in general into the abſorbent veſſels of animals, depends on an action like to that of the lips and mouth of animals in eating.

We

We are, on the contrary, from the facts above ftated, led to the conclufion, that the abforbent tube is, by its proper mufcular action, and perhaps alfo by an influx of liquors into the arteries which are difperfed on its coats, made tenfe, and its cavity at the fame time much contracted: in confequence of which it acquires the property of a glafs capillary tube, of attracting liquors; which, by the well-regulated action of its mufcular fibres, are pufhed onward from their entrance to their termination.

Thefe abforbent tubes ferve for the farther purpofe, which at firft fight we fhould not have expected, of feizing and fecuring the buccina, on which the animal preys.

I was led to fufpect this from obferving, that when I put them into a glafs-veffel with water, in order to view the action of their abforbent veffels, they fixed themfelves by their abforbent tubes to the fides of the glafs.

It immediately occurred to me, that, by a fimilar action, they might fecure the fhelled worms, on which I knew they preyed, as I had found particles of fhells in their alimentary canal.

I therefore directed the fifhermen to bring me, along with the echini, fome living buccina: to which, as I had fuppofed they would do, they attached themfelves fo effectually, that when I lifted the echinus out of the water, I found it could fupport with eafe a buccinum which weighed nearly a quarter of a pound.

Perhaps, for this particular purpofe, the plate at the mouth of the abforbent, which they apply as a boy does a piece of wetted leather to a ftone, is fo conftructed as to be made flat; while, for the abforption of liquors, it is pufhed out into a conical fhape, and has its orifice contracted.

EXPLANATION

EXPLANATION

OF THE

TABLES.

TABLE I.

THE figures of this Table reprefent the extent of the furface of the gills, the heart, the branchial arteries and veins, and the aorta, of a fkate, filled with injection.

The figures 1, 2, 3 of this Table ferve to fhow the extent of the furface of the gills of a fkate.

Fig. 1. Shows a procefs or divifion of the gills of its natural fize.

Fig. 2. Shows the fame magnified with a glafs.

Fig 3. Shows the appearance, with a magnifying glafs, of the leaves into which the proceffes or divifions of the gills are fubdivided.

Figures 4. and 5. of this Table reprefent the heart, the branchial arteries and veins, and aorta, of a fkate, filled with injection.

FIG. 4. gives a fore view of,

A, The auricle of the heart.
B, The ventricle of the heart.
C, The root of the branchial artery.

D, The place at which the three femilunar valves are fituated (fee Tab. II. 40.) Between this place and the ventricle the root of the artery has the fame red colour and texture as the ventricle itfelf; but beyond the valves, the artery becomes much thinner and of a white colour.

E E, The two firft branches of the branchial artery fent off at nearly right angles, and each of them dividing into three branches.

K L M, Which are fpent on the three undermoft pairs of gills K L M.

F, The continuation of the trunk of the branchial artery, which divides into two equal branches G G; each of which is fubdivided into two branches H I, which are fpent on the two uppermoft pairs of gills H I.

That the courfe of the blood may be more eafily traced, I fhall now drop the farther explanation of fig. 4. and proceed to

The Explanation of Figure 5.

The fternum, the heart, and branchial artery, the whole tract of the alimentary canal and chylopoietic vifcera, the bafis of the cranium and bodies of the uppermoft vertebræ, are cut away, in order to give a full view of the branchial veins and the aorta.

1, Reprefents the mouth.

2, The fore part of the cavity of the cranium, which was filled with a vifcid fluid.

3, The anterior lobes of the brain.

4, A middle cineritious lobe.

5, The cerebellum.

6, The fpinal marrow.

7, The olfactory nerve.

8, The optic nerve.

9 and 10, Nerves refembling the third and fourth pairs in man.

11, A very large nerve which refembles our fifth pair.

12 and 13, Nerves which have fome refemblance to our feventh and eighth pairs.

14, Nerves refembling our ninth and fub-occipital nerves; and below this place the nerves of the fpinal marrow are feen.

15, The inferior or pofterior femicircular canal of the ear.

16, 17, 18, 19, and 20, Show the back part of the openings into the throat under and between the gills, through which the water paffes in refpiration.

21, The mufcles in the fide of the fifh.

22, The fore part of the vertebræ.

23 and 24, The tefticle and epididymis flightly fketched.

25, The termination of the dilated end of the vas deferens or veficula feminalis in the common cloaca.

26, The

26, The kidney.

27, The bladder of urine and urethra of the right ſide.

28, An opening on the outſide of the ſphincter ani, by which there is a paſſage from the cavity of the abdomen.

A A, Repreſents the trunk of the branchial vein in the uppermoſt gill which is ſingle, or has the blood from the branchial artery diſperſed on its under ſide only.

B, The direct continuation of A, which conveys the blood to the noſe and other external parts of the head, ſerving the office of an artery.

C, A communication of A with D, the uppermoſt branchial vein of the ſecond gill, which is double.

E, A trunk formed by C and D joining.

F F, Small arteries ſent off from this trunk to the muſcles and other external parts of the head.

G, A communication of D, the upper branchial vein of the ſecond gill, with H the under branchial vein of the ſame gill.

I, The upper branchial vein of the third gill.

K, A trunk formed by the joining of H and I.

M, A trunk formed by the joining of E and K.

L L, Two large arteries, from which chiefly the top of the ſpinal marrow, the cerebellum, and brain, are ſupplied; and which communicate, freely and repeatedly, with each other. Other ſmall arteries derived from B and F enter the cranium.

N, A large trunk formed by the joining of M M.

O, The joining of I with P, the under branchial vein of the third gill.

Q, The upper branchial vein of the fourth gill.

R, The trunk formed by the joining of P and Q.

S, The communication of the upper and under branchial veins of the fourth gill.

T, A trunk formed by the joining of R R with N; which therefore receives blood from the three uppermoſt gills and one half of the fourth.

U U, Two large arteries from the ſides of T; each of which divides into two principal branches *a* and *b b;* one of which, *b b*, ſupplies the numerous muſcles on the ſide of the fiſh, whilſt the other, *a*, runs upwards on the fore part of the anterior ends of the gills, and there at *c* communicates freely with the outer ends of all the branchial veins *d d d*, which are at the ſame place connected to each other; ſo that they form ovals around the openings between the different gills. From the great branch *a* other arteries are ſent off: for a view of which the reader will now return to the

Further

Further EXPLANATION of FIGURE 4. in which P reprefents the Branch *a* of Figure 5.

From P are fent off,

QQQ, Branches dividing into fmaller parts upon the outer fides of the gills; and which appear to me analogous to our bronchial arteries.

RRRR, The branches which fink deep, and in Fig. 5. were feen joined to the branchial veins at the outer end of the ovals they form.

S S, Arteries fent to the pericardium and heart, analogous to our coronary arteries.

T U, The termination of this artery in the mufcles and other parts of the upper jaw.

The reader will now turn again to the 5th figure, to finifh what remains to be explained concerning the joining of the branchial veins and courfe of the blood in the aorta.

V, Reprefents the upper branchial vein of the fifth gill, joined to W the undermoft branchial vein.

X X, A trunk formed by the joining of S V and W.

Y, The trunk of the defcending aorta.

c d, The cæliac and mefenteric arteries.

e e e e e e e e e e, Arteries fent off to the organs of generation and urine.

f f, Two large arteries to the lower part of the trunk and fins at the fides of the anus.

g, The termination of the aorta running into the tail, where it is covered and protected by the vertebræ.

TABLE II.

IN this Table the thoracic and abdominal vifcera, with the circulating veins, of a female fkate cut open, are reprefented.

1, 1, The organs of fmell.

2 and 3, The upper and under jaws.

4, The œfophagus.

5, The ftomach.

6, The pylorus.

7, The fmall gut.

8, The appendix vermiformis or cæcum.

9, The right lobe of the liver.

10, The gall-bladder.

11, The

11, The middle lobe of the liver.

12, The fpleen.

13, The pancreas.

14, The lower part of the right kidney.

15, The ovarium or egg-bed of the right fide.

16, 16, The mouths of the two uterine or Fallopian tubes, with probes introduced into them.

17, A white glandular organ, through which the right uterine tube paffes.

18, The uterus of the right fide filled with a complete egg.

19, 19, The cavity of the pericardium.

20, The ventricle of the heart turned upwards, after being cut away from

21, The diaphragm.

22, 22, 22, and 23, 23, 23, Two probes paffed behind the heart into a funnel-like tube, which, below, divides into two branches connected to the œfophagus; by which the cavity of the pericardium communicates with the cavity of the abdomen.

24, Reprefents the lower part of the right vena cava abdominalis; at which place there is a very large receptacle of the blood covered by the ovarium, the root of which only appears here; and even that is imperfectly fhown.

25, The opening of the renal veins into the cava.

26, Large paffages by which the two cavæ communicate.

27, The top of the right abdominal cava.

28, A large vein from the mufcles and other parts behind the abdomen.

29, A large vein from the abdominal mufcles and fide of the fifh.

30, A large vein refembling our pofterior external jugular.

31, A receptacle formed by the venæ cavæ hepaticæ; the diameter of which is ten times greater than that of the opening from the receptacle into the cava, into which a probe is put.

32, Dotted lines, marking the fituation of a tranfverfe vein which joins the right and left venæ cavæ hepaticæ, and receives into it the middle vena cava hepatica.

33, 33, The right internal jugular vein; at the termination of which there is a pair of valves.

34, A fmall vein, fomewhat like to our anterior external jugular.

35, The termination of the left vena cava, which is compofed of branches exactly correfponding with thofe of the right fide.

36, The termination of the lacteal and lymphatic veffels, or of the lymphatic fyftem, into the trunk of the great vein which refembles our fubclavian, and which next receives the internal jugular vein. At this termination there is a pair of valves, which perform their office with great accuracy. So that the termination of the lymphatic fyftem in the fkate refembles the termination of that fyftem in man, both as to place and ftructure.

As there are two venæ cavæ of equal fize, fo we fhall find that the termina-

 tions

tions of the lymphatic fyftem on the two fides correfpond nearly in all refpects.

37, 37, Two principal coronary veins of the heart.

38, The meeting of the two venæ cavæ, and their opening into the auricle of the heart.

39, The upper end of the flefhy cylindrical root of the branchial artery laid open.

40, Three femilunar valves; in the middle of each of which there is a round fubftance, refembling in office, but not in fhape, the corpufculum Arantii.

41, 41, The two firft large branches of the branchial artery.

42, The continuation of its trunk.

43, 43, The other two branches by which the branchial artery terminates in the gills.

TABLE III.

THIS Table fhows fully the arteries and circulating veins of the chylopoietic vifcera of a fkate, with a flight fketch of the lacteals, all filled with injection.

AA, The œfophagus.

B, The ftomach.

C, The pylorus.

D, The fmall inteftine.

E, The appendix vermiformis.

F, The common cloaca.

G, The pancreas.

H, The fpleen.

I, K, L, The right, middle, and left lobes of the liver.

M, The gall-bladder.

N, A glandular body, through which the uterine tube paffes into O, the uterus of the right fide.

P, The fpine.

Q, The aorta defcendens.

R, An artery like to our cæliac, fupplying by its branches S T U U, the liver, ftomach, fpleen, and pancreas.

V W, An artery refembling our fuperior mefenteric artery.

X X. The inteftinal veins.

V Z Z, Veins from the pancreas, pylorus, fundus of the ftomach, and left fide of the fpleen.

a a, A large vein formed by the meeting of all the above-mentioned veins.

b b, Veins from the leffer curvature of the ftomach and reft of the fpleen.

c, The trunk of the vena portarum.

def, Three

def, Three great branches into which the vena portarum divides, and which are difperfed like arteries in the liver for the fecretion of the bile.

ghh, A faint fketch of the lacteals from the fmall inteftine.

iii, Lacteals from the fundus of the ftomach joined by lymphatics from the fpleen and pancreas.

k, A plexus where the above-mentioned lacteals and lymphatics communicate.

ll, Lymphatics from the fpleen and lacteals from the leffer curvature of the ftomach.

mm, Lymphatics from the gall-bladder.

nn, Lymphatics from the liver.

o, Lacteals from the œfophagus.

pq, A large and intricate plexus of the trunks formed by all the above-mentioned lymphatics and lacteals, which runs upwards and forwards between the œfophagus and fpine connected to the cæliac and mefenteric arteries.

TABLE III*.

This Table reprefents the mufcular coat of the root of the fuperior mefenteric vein of an Ox, where it is about to join with the other veins, to form the vena portarum.

A, The outer furface of the root of the fuperior mefenteric vein of an ox.

B, The external layer of the mufcular coat, which confifts of longitudinal fibres; raifed from C, the internal layer of the mufcular coat, which confifts of tranfverfe or circular fibres.

TABLE IV.

In this Table the lungs, the heart, and large veffels of a fea-tortoife or turtle, are reprefented. The heart and blood-veffels were filled with wax, and the cells of the lungs with air, and dried before the drawing was made.

A, The trunk of the trachea divided into two branches B C.

D, The lungs on the right fide entire, and E the cells of the lungs on the left fide cut open.

F, The right auricle of the heart.

G, The left auricle.

H, The right ventricle.

I, The left ventricle.

K K, The left pulmonary artery.

L, The right pulmonary artery.

M N, O, Three arteries which fupply the place of our aorta.

P, Branches of the coronary artery which comes off from M.

Q, R, The right and left pulmonary veins.

The two venæ cavæ, with the coronary vein, open into the back part of the right auricle.

TABLE V.

This Table reprefents, in a cod fifh, the upper end of a large lymphatic veffel fituated on the fide of the fifh; and likewife mucous ducts, from which branches are fent off that terminate on the furface of the fkin.

1, 2, 3, The upper and under jaws and the mouth.

4, The right eye,

5, The gill-flap.

6, The fin on the fide.

7, The fin on the back.

8, The termination of a large lymphatic, which begins at the tail, and runs upwards on the fide of the fifh, receiving its branches from the fkin and mufcles of the trunk at nearly right angles. The pairs of its branches are here feen.

9, The upper end of a mucous duct, which runs upon the fide of the fifh nearly parallel with the laft lateral lymphatic, and which has numerous fhort branches, with open mouths, which pour out mucus upon the furface of the fkin.

10, 11, 12, 13, 14, 15, 16, 17, Show the continuation of the fame mucous duct cut open, dividing at 11 into two great branches, which have blind ends at 15 and 17, and at 12 communicate with fimilar ducts on the other fide of the head.

18, 18, 18, &c. Are fhort branches, with open mouths, which pour out mucus upon the furface of the fkin.

19, 19, 19, Another large mucous duct, which is fhut at both ends, and has no communication with the former; and which difcharges its mucus upon the furface of the fkin of the under jaw by nearly the fame number of open mouthed fhort branches 20, 20, 20, 20, 20, &c. as have been fhown under the eye terminating on the furface of the upper jaw.

TABLE

TABLE VI.

THIS Table reprefents chiefly the mucous ducts on the fore part of a Skate.

1, 1, The nofe.

2, 3, The two jaws with the teeth.

4, 5, 6, 7, 8, Five openings or fpiracula on the left fide, to wit, one under each of the gills.

9, The centre from which innumerable mucous ducts come out, like rays from the centre of a circle.

10, 11, 12, Bundles of mucous ducts running outwards to different parts of the furface of the body.

13, 14, A large bundle of the mucous ducts running inwards, to open on the furface of the fkin of the breaft. At 14 many of their openings appear with briftles introduced into them.

ABCCCCDEFGHIKL, Large and picturefque canals, which naturally contain mucus, injected with wax; and which are fo diftinctly feen, that it is needlefs to be very particular in the defcription of them. A, is a blind end. CCC, are a few fhort branches, which by open mouths pour out mucus on the furface of the fkin. From H a large branch is fent to the back part of the fnout. From K the mucous duct makes a turn to the upper and back part of the fifh.

TABLE VII.

THIS Table reprefents the mucous ducts on the back part of a Skate, and its meatus auditorii externi.

FIG. 1. AB, Two round holes, which make the beginning of the paffage into the ear. Behind thefe the head is joined to the fpine.

FIG. 2. Reprefents in a fkate the paffage through the fkin into the concha of the ear; the concha laid open, and the beginning of the meatus from it to the internal ear, all feen from the under or anterior fide.

a a, Probes in two holes through the fkin, leading into the conchæ of the ear.

b b, The beginnings of the conchæ, of a funnel-like fhape.

c c, The winding of the conchæ.

d, A probe paffed from the right concha into the beginning of the meatus from the concha to the internal ear.

e, The beginning of the left meatus cut open.

f, The feptum between the conchæ or external ears.

FIG. 3.

1, The fnout.

2, 2, The eyes, in which a digitated portion of the iris is imperfectly feen; which, like a curtain, may darken the pupil.

3, 3, Two large paffages into the throat.

4, 5, Two fmall holes, which make the beginning of the paffage into the ear.

6, 7, At 6 a probe is put in; at 7 an incifion is made, where the end of that probe is directed outwards and downwards; by which means a large cavity and winding paffage from it are feen, refembling the fcapha and concha of our ear. A thick membrane feparates the two conchæ from each other.

8, A fmall hole, capable of receiving a briftle; which is the beginning of a canal that refembles our meatus auditorius, and leads into the internal ear.

9, The centre at which all the bundles of fmall mucous ducts begin on the left fide.

10, 11, 12, 13, 14, The bundles of mucous ducts in their courfe to diftant parts of the furface of the body.

15, 15, 15, &c. The open mouths of the mucous ducts, with probes put into many of them.

16, 17, A large nerve, dividing into a great number of fmaller nerves; moft of which are fpent upon the fhut beginnings of the mucous ducts.

Thefe fmall nerves are white and opaque till they are connected to the beginnings of the mucous ducts, when the nerves become tranfparent like thefe ducts, and fo difappear.

G K H, Show the beginning of the ducts G K at H, reprefented in the fore view of the large mucous ducts Tab. VI.

I, Likewife reprefents the fame duct as the fore view did; being feen on both fides from the thinnefs and tranfparency of the dried fnout of the fifh.

O, Reprefents a large branch reflected from H, upwards and backwards, and terminating by half a dozen fmall branches, which have mouths opening upon the furface of the fkin at the fore part of the orbit.

L, Is the mucous duct marked with the letter L in the fore view, and which is here feen reflected and fending off at M M N about ten fmall branches, which difcharge themfelves upon the furface of the fkin.

TABLE

TABLE VIII.

THIS Table, of ſome parts of a Sturgeon, is chiefly intended to ſhow two holes or canals placed at the ſides of the anus, through which liquors effuſed into the cavity of the abdomen may be readily diſcharged; and two other holes, at the bottom of funnels, by which the cavity of the abdomen communicates with the pelves of the kidneys.

In FIGURE 1ſt,

A, Repreſents the upper and B the under part of the milt or teſtis of the male.

C, The inteſtinum rectum entire, and D the anus ſlit open.

E F G, The pelvis of the left kidney cut open in three places, and the orifices of the infundibula, which diſcharge the urine into it, ſeen.

H I, The lower end H of the pelvis of the left kidney, joined with I, the lower end of the pelvis of the right kidney.

K, An outlet or urethra common to the two kidneys.

L M, A membrane, which forms the fore part of a funnel N O, and which, by a hole P at its under part, communicates with the middle part of the pelvis of the kidney.

Q R and S, Two probes paſſed from the cavity of the abdomen, out at two holes placed at the ſides of the inteſtinum rectum.

FIG. 2.

In this figure C D repreſent the inteſtinum rectum.

G, Part of the pelvis of the kidney cut open.

Q R, A probe put into the hole or outlet from the abdomen which is at the right ſide of the anus.

TABLE IX.

THIS Table repreſents principal parts of the ſtructure of the abdominal bowels in a ſmall female Skate.

FIG. 1.

A A, The fore part of the body.

B, The lower end of the ſtomach.

C, A plexus of the lacteals and cellular receptacle of the chyle.

D, The

D, The valve of the pylorus.

E E, Many doublings or valvulæ conniventes within the ſmall gut, which was ſlit open lengthwiſe.

F, The appendix vermiformis.

G, The right lobe of the liver.

H, The middle lobe of the liver.

I, The left lobe of the liver.

K, The gall-bladder and beginning of the cyſtic duct cut open.

L, A principal hepatic duct.

M, The ductus communis choledochus.

N, Its termination a little under or behind the pylorus.

O, Part of the ſpleen.

P, The opening of the pancreatic duct at ſome diſtance from that of the biliary duct.

Q, An oval mouth, common to the two uterine or Fallopian tubes R R.

S, A ligament which ties that mouth to the diaphragm.

T, The vena cava inferior or poſterior of the right ſide.

U, The place where the two inferior or poſterior venæ cavæ are ſenſibly enlarged, and communicate with each other.

V, One of two large receptacles of blood which communicate with the poſterior venæ cavæ, and behind cover part of the ovaria.

Fig. 2.

In this figure the appendix vermiformis of a very large ſkate is repreſented cut open lengthwiſe.

A A, The ſides of it very thick, compoſed of a fibrous and glandular-looking matter.

B, Cells which ſeem to receive a viſcid mucous liquor prepared by the glandular ſubſtance.

C, The opening from the cavity of the appendix into the cavity of the great inteſtine.

TABLE IX*.

This Table is intended to ſhow a beautiful reticular ſtructure of the pancreas, and of the villous coat of the inteſtines, of a Sturgeon.

A, A ſmall part of the ſtomach cut open, and a probe paſſed from it through B the pylorus.

C D, A portion of the duodenum laid open, to ſhow the reticular texture of its villous coat.

EF,

E F, The pancreas laid open, to ſhow the reticular texture of its inner ſide, and the manner in which the ducts from it are conjoined.

At E a layer of muſcular ſubſtance is delineated, covering and incloſing the reticular part.

G H I, Smaller ducts ending in larger.

K, The edge of a large circular opening, by which the pancreas diſcharges its liquor into the duodenum.

TABLE X.

In this Table are repreſented the biliary ducts of a Cod; with the termination of their inteſtinula cæca, which are analogous to our pancreas.

A, Part of the ſtomach ſlit open.
B, The pylorus ſlit open.
C, The duodenum or firſt gut.
D D D D, The mouths of the inteſtinula cæca, analogous to our pancreas.
E E E E, Four hepatic ducts.
G G G, Terminations of the hepatic ducts in a ſpheroidal bag H.
I, The gall-bladder.
K, The cyſtic duct.
L L, A probe in the ductus communis choledochus, terminating in the duodenum.

TABLE X*.

This Table repreſents the liver and biliary ducts of the Wolf or Cat Fiſh, or G. 146. Anarhichas of Linnæus.

A B, The right and left ſides of the liver.
C, The gall-bladder.
D, The ductus communis choledochus running down to the duodenum.
E F, Numerous hepato-cyſtic ducts.
G, Biliary hepatic ducts, terminating in the neck of the gall-bladder and upper part of the ductus communis choledochus.

TABLE XI.

This Table reprefents the organs of generation and urine in the male Skate.

A A, The containing parts of the abdomen.
B, The diaphragm.
C, The fpine.
D, The appendix vermiformis.
E, The common cloaca.
F, A large branch of the left inferior vena cava.
G, A large cavernous receptacle common to the two venæ cavæ inferiores, but communicating chiefly with the right cava.
H, A large probe paffed from the right cava into the cavernous receptacle.
I I, The two tefticles.
K, A white medullary part of the right tefticle.
L L, Lobes in the tefticles.
M, Threads or tubes, by which the teftis is connected to the epididymis,
N, Which is compofed chiefly of convoluted tubes.
O, Part of the epididymis which is not evidently tubular.
P, The ferpentine vas deferens.
Q, The termination of the dilated end of the vas deferens, or veficula feminalis.
R, A fac, which contains a vifcid dark green-coloured humour.
S, An opening from R, contiguous to the opening from the vas deferens.
T, The kidney.
U, The ureter.
V, The termination of the ureter.
W X, A fection of the lobular or glandular part of the tefticle L, viewed with a magnifying glafs, which is compofed of minute fpherical portions.

TABLE XII.

This Table reprefents the organs of urine and part of the organs of generation in the male Skate.

A, The bodies of the vertebræ.
B B, The loins, and containing parts of the abdomen.
C, The left kidney.
D, A briftle put into the ureter on the left fide.
E, The left vas deferens greatly enlarged at its inferior or pofterior end.

FF,

F F, The termination of the vas deferens, entire on the right ſide, but ſlit open on the left ſide.

G G, A large ſac on each ſide, which contained a green-coloured liquor, and which diſcharges itſelf at the ſame place with the vas deferens.

H, The ſeptum between it and the vas deferens on the left ſide.

I, A funnel or papilla, analogous to the penis, by which the urine, the ſemen, and liquor of the two ſacs G G are diſcharged into K K, the termination of the rectum or common cloaca.

L L, The terminations of two outlets from the cavity of the abdomen.

M, A probe paſſed from the cavity of the abdomen on the right ſide through the outlet L.

TABLE XIII.

In this Table are repreſented the openings of the two uteri of the Skate, and the opening of the veſica urinaria into the common cloaca.

A, The end of the rectum.
B, The common cloaca.
C, The verge of the anus.
D D, The ends of the paſſages from the cavity of the abdomen.
E E, The lower ends of the two uteri.
F F, The openings of the uteri into the common cloaca.
G, The bladder of urine cut open.
H, The termination of the urethra with a probe in it.

TABLE XIV.

In this Table, which repreſents the fœtus of a Skate, with its pericardium and abdomen cut open, the yolk is ſhown connected to the inteſtinal tube.

A, The ſnout of the fœtus.
B, Its left ſide.
C, Its tail.
D D, Fins near the anus, which are large, and armed in the male.
E E, The noſtrils.
F, The mouth.
G, The heart.
H H, The abdominal muſcles and peritonæum cut and turned back.
I I I, Three lobes of the liver,
K, The ſtomach near the pylorus.
L, The ſmall inteſtine.

M, The

M, The appendix vermiformis or cæcum.

N, The anus.

O, The yolk of the ovum.

P, The duct by which the yolk paffes into the alimentary canal under the pylorus, and near the beginning of the inteftinal tube or fmall inteftine.

TABLE XIV*.

THIS Table reprefents the yolk and young fœtus of a very large Skate.

A, The mouth of the fœtus.

B, Its left eye.

C, The flefhy fide of the fœtus.

D, The tail of the fœtus.

E, Numerous veffels, which were full of red blood, and floated loofe in the glaire or albumen of the egg. Thefe veffels fupply the place of the gills, and feem to be afterwards covered and converted into the gills.

F, The duct which connects the yolk to the fmall gut of the fœtus.

GHI, Numerous veffels conveying red blood, elegantly difperfed in the yolk; their trunks running along the duct F, and connecting the veffels of the fœtus with thofe of the yolk.

TABLE XV.

THIS Table reprefents, in the Salmon, the Carp, and the Herring, a duct, by which the fwimming-bladder communicates with the œfophagus or ftomach: and in the Cod a red foliated organ, placed on the inner fide of the fwimming-bladder.

FIG. 1. From the Salmon.

A, The upper part of the right roe.

B, The œfophagus cut open.

C, The anterior or upper end of the fwimming-bladder cut open.

D, A probe paffed from the fwimming-bladder into the œfophagus, through a large duct E, by which they communicate.

FIG. 2. From a Carp.

A, The fuperior or anterior fwimming-bladder.

B, Part of the pofterior fwimming-bladder.

CD,

C D, A paſſage or duct by which theſe two bladders communicate with each other.

E F, A large tube, by which the poſterior ſwimming-bladder communicates with,

G, The œſophagus or upper part of the ſtomach. In ſeveral ſpecies of carp, and in the perca arenaria, I found the ſtructure ſimilar.

F I G. 3.

Repreſents a Herring, with the containing parts of the abdomen on the right ſide cut and turned back. The right roe is cut away; the left roe L extends the whole length of the abdomen.

A, Is the œſophagus.
B, The ſtomach.
C, The duodenum.
D, The appendices cæcæ.
E F, The poſterior part of the gut and the anus.
G H, The ends of the ſwimming-bladder.
I, The poſterior part of the ſtomach, of the ſhape of a funnel, and terminating in a duct K; by which the ſtomach and the ſwimming-bladder communicate with each other. This funnel and duct are placed between the roes in the female, and between the milts in the male.

F I G. 4.

Repreſents the red, vaſcular, foliated ſubſtance placed on the inner ſide of the air-bag of a Cod.

F I G. 5.

Repreſents a ſmall portion of the above-mentioned red, vaſcular, foliated ſubſtance, viewed with a magnifying glaſs.

T A B L E XV*.

THIS Table repreſents the heart, ſtomach, air-bag and air-duct, of the Conger or Sea Eel.

A, The pericardium opened.
B B, The auricle of the heart.
C, The ventricle of the heart.
D, The branchial artery.

E, Ligaments which connect the ventricle of the heart to the pericardium.

FG, The lower part of the œſophagus and upper part of the ſtomach laid open.

H, The under end of the ſtomach.

I, The pylorus.

K, The beginning of a duct from the lower end of the œſophagus to the air-bag.

LM, A probe paſſed from the lower end of that duct into O the air-bag.

NN, Two red ſpheroidal bodies placed at the ſides of the entrance of the air-duct into the air-bag.

TABLE XVI.

The three firſt figures of this Table repreſent, of its natural ſize, the communication of the air-bag with the upper part of the ſtomach in the Sturgeon.

Fig. 1.

A, Repreſents the lower end of the œſophagus.

BC, The inner ſide of the back or upper part of the ſtomach.

D, A very large hole in the ſeptum between the ſtomach and air-bag, by which theſe two cavities communicate with each other.

Fig. 2.

In this figure the villous coat of the ſtomach is diſſected off from the edges of the hole by which the ſtomach communicates with the air-bag.

EE and FF, The villous coat raiſed by diſſection.

GHIK, A thin muſcular coat; the fibres of which form an oval around the hole D, and decuſſate each other at its upper part.

Fig. 3.

Shows the ſame hole, by cutting open the back part or upper part of the air-bag.

D, The hole.

ML, The inner ſide of the air-bag.

N, Doublings of the inner membrane of the air-bag at the ſide of the hole D.

Fig. 4.

Repreſents a portion of the inteſtine of the Sturgeon cut open, in order to ſhow

ſhow an elegant reticular texture of its inner coat and large branches of the meſenteric veins, which have very thick coats placed in a ſingular manner on the villous coat.

O P Q R, The reticular texture of the villous coat.

S T U W, Branches of the meſenteric vein.

TABLE XVII.

THIS Table repreſents the abdomen laid open in a female Frog.

FIG. 1.

A, The mouth.

B, The cartilago enſiformis.

C, The heart and pericardium ſeen through the membranous diaphragm.

D, The two air veſicles or lungs collapſed.

E F, The ſeveral lobes of the liver.

G, The gall-bladder.

H, The pancreas.

I, The ſpleen.

K, Fatty pelotons, which ſeem to ſupply the office of omentum.

L, The ſtomach.

M, The ſmall inteſtines.

N, The end of the ſmall and beginning of the great inteſtine.

O O, The ovaria full of ova.

P, The mouth or beginning of the right oviduct or Fallopian tube fixed to the diaphragm. A probe is put into it.

Q R, The continuation and convolutions of the uterine tube.

S, The termination of the uterine tube in T the uterus.

FIG. 2.

Repreſents, with a magnifying glaſs, the ſhape and different ſizes of the ova. The larger are black-coloured; the ſmall ones are not black.

TABLE

TABLE XVIII.

In this Table, the abdominal viſcera of a Skate, with the lacteal and lymphatic veſſels injected with wax, and their termination on the right ſide, are repreſented.

Fig. 1.

1, 1, The two noſtrils and organs of ſmell.

2 and 3, The two jaws and teeth.

4, 5, 6, 7, 8, The five gills on the right ſide.

9, The œſophagus.

10, 11, 12, A funnel, with a probe in it, from the bottom of the pericardium, dividing into two pipes; which, upon the ſide of the œſophagus, open into the cavity of the abdomen.

13, The ſtomach.

14, The pylorus.

15, The ſmall inteſtine.

16, The appendix vermiformis or cæcum.

17, The common cloaca and anus.

18, 19, 20, Three lobes into which the liver is divided.

21, The gall-bladder.

22, The place at which the ductus communis choledochus terminates.

23, The ſpleen.

24, The pancreas.

25, The ovarium.

26, Part of the Fallopian tube or oviduct.

27, A glandular white body through which the oviduct paſſes.

28, The uterus containing an ovum.

29, 29, A probe paſſed from a hole at the ſide of the anus into the abdomen.

30, A kind of valve, which renders the entrance of a probe from without difficult, but allows it to paſs readily from the cavity of the abdomen outwards.

31, The kidney.

32, The ſpine.

A, Lacteals from the upper part of the great gut, the cæcum, and ſmall inteſtine.

B, Lacteals from the pylorus, and lymphatics from the pancreas.

C, Lacteals from the leſſer curvature and right ſide of the ſtomach.

D, A trunk which receives lymphatics from the ſpleen and ſome lacteals from the ſtomach.

E,

E, A bundle of lacteals from the leffer curvature and anterior flat fide of the ftomach.

F G, Numerous lymphatics from the liver and gall-bladder.

H, Their joining with the before-mentioned lacteals and lymphatics.

I K, A large plexus of the lacteal and lymphatic veffels in their way upwards along the œfophagus. From I, many branches pafs over to the left fide; or, at this place, there are numerous anaftomofes between the lacteals and lymphatics of the right and left fides.

L, Other lacteals, making a net-work on the œfophagus, and joining with the large plexus at K.

M, Lymphatics, running upwards along the fpine from the great gut and organs of urine and generation, and lower parts in general, and ending in the plexus K.

N O P, Lymphatics from the back and fides of the fifh.

R S T U V W, The branches and trunk of a very large lymphatic veffel, which brings the lymph from the brain, ear, eye, nofe, cranium, both jaws, the gills and neighbouring mufcles.

Y, Other fmall deep-feated lymphatics coming out from behind the heart.

X, The meeting of all the lacteal and lymphatic veffels, and termination of that fyftem in the vena cava, as fhown in Tab. II. fig. 36.

Z, A large cavernous plexus of the lacteals on the great curvature of the ftomach.

Explanation of Figure 2.

This Figure fhows the appearance and anaftomofes of the lymphatics running on the back part of the mufcles at the fides of the head, and which terminate in the trunk of the great lymphatic veffel in fig. 1. marked with the letters R S W.

A, A centre from which the mucous ducts come out; which are fully reprefented in Table IX.

B, The trunk of the lymphatic, diftinguifhed in fig. 1. by the letter S.

C C, Smaller branches in a regular way, or nearly at right angles.

D D, Other branches joining the former together. Several branches are larger than thofe from which they proceed, or appear varicofe, yet have no valves.

TABLE XIX.

In this Table are reprefented the heart and abdominal vifcera of a Skate, with their lacteal and lymphatic veffels injected with wax, and their termination on the left fide.

1, 1, The nofe.
2, 3, The upper and under jaws.
4, The place of the gills.
5, The auricle of the heart.
6, The ventricle of the heart.
7, The root of the branchial artery.
8, The œfophagus.
9, The cardia.
10, The body of the ftomach.
11, The pylorus.
12, The fmall inteftine.
13, The place at which the great gut begins.
14, The appendix vermiformis.
15, The anus, and common cloaca within it.
16, 17, 18, The three lobes of the liver.
19, The fpleen.
20, The pancreas.
21, The ovarium.
22, The glandular body, which is connected to the uterine or Fallopian tube.
23, The body of the left uterus.
24, The os uteri going into the common cloaca.
25, The left kidney.
26, A probe paffed from the cavity of the abdomen into a hole at the fide of the anus.
27, The fpine.

A, A bundle of large lacteal veffels paffing upwards from the fmall inteftine towards the pancreas.

B, Lymphatics from the pancreas joining thefe.

C, D, The lacteals from the great curvature of the ftomach, forming a reticular cavernous fubftance.

E, Other lacteals from the pylorus and top of the fmall gut added to the above, and forming a plexus of branches, which runs upwards along the upper end of the pancreas.

F, The joining of the lacteals from the great curvature of the ftomach with the

the lacteals from the fmall inteftines and the lymphatics from the pancreas; at which place their branches form a very beautiful but very intricate plexus.

G H, Numerous lacteals from the pofterior flat fide of the ftomach.

I, Numerous lymphatics from the fpleen.

K, The place behind the cardia, at which the lacteals from all parts of the ftomach and fmall inteftines, and the lymphatics from the pancreas, the fpleen, and the liver, meet and communicate freely; and from which large and intricate plexufes, of nearly equal fize on the right and left fides, are fent upwards along the œfophagus.

L. Lacteals from the œfophagus added to the continuation of the left plexus.

M, A bundle of lacteals from the appendix vermiformis and large inteftine, and lymphatics from the kidney and uterus running upwards along the fpine, to join the above-mentioned plexus.

N, Other lymphatics from the top of the ovarium, and from the mufcles of the back added to the plexus.

O, Numerous fmall lymphatics added from the parts behind the pericardium.

P, Large lymphatics from the mufcles and other parts in the fide of the fifh.

Q, Some nerves left, which refemble thofe of our fubclavian plexus, and which conceal the termination of the great lymphatic trunk from the upper parts of the fifh, reprefented in Table XVIII. at the letters R S W.

R, The termination, on the left fide, of the lacteal and lymphatic veffels in the fubclavian vein or left vena cava. At this place a pair of valves, reprefented at R, is conftantly found.

S, The end of the left internal jugular vein, at which there is always a pair of valves, exactly like to thofe at the termination of the lymphatic fyftem.

If the Reader will now take the trouble of comparing R S of this Table with X, Table XVIII. or with Table II. numbers 36 and 33, he will find that the lymphatic abforbent veins, as well as the circulating red veins, terminate in nearly the fame manner on both fides of the Skate.

TABLE XX.

This Table reprefents the ftructure of the vafcular and cellular receptacle of the chyle, fituated on the large curvature of the ftomach of a Skate.

Fig. 1.

A, The upper, and B the under, end of the ftomach of a fmall Skate, moderately filled with air.

C D, The vafcular and cellular receptacle of the chyle cut open, after it had been kept inflated till it was dried.

Fig.

Fig. 2.

Reprefents a part of the fame as it appears through a magnifying glafs. In both, C reprefents lacteal veffels cut lengthwife.

D, Cells furrounding and communicating with lacteal veffels.

TABLE XXI.

This Table reprefents the injected lymphatic veffels of the brain, the ear, the eye, and fkin of the Skate.

Fig. 1.

Reprefents the lymphatic veffels of the fkin injected.

Fig. 2.

Reprefents the fame viewed with a magnifying glafs. Their branches communicate every where by innumerable lateral anaftomofes.

Fig. 3.

Reprefents the upper part of the brain, the eye, and ear, of a Skate dried; the lymphatics of which had been previoufly well injected.

A, Part of the fnout of the fkate.

B, The left eye, on the adnata and iris of which many lymphatics are injected.

CDE, The brain and cerebellum, on which, and on the dura mater or membrane lining the cranium, many lymphatic veffels are injected. At D, particularly, an intricate plexus of the lymphatics is found.

EF, Lymphatic veffels of the fpinal marrow.

G, Numerous lymphatic veffels on the fac of the ear which contains cretaceous matter.

H, A large cutaneous thorn.

Fig. 4.

D, Reprefents, with a magnifying glafs, the anaftomofes of the lymphatic veffels of the brain, which form the plexus D in fig. 3.

H, The thorn H of fig. 3.

F I G. 5.

Reprefents, viewed with a magnifying glafs, lymphatic veffels difperfed on the fac of the ear or labyrinth which contains cretaceous matter.

T A B L E XXII.

In this Table are reprefented the heart and abdominal vifcera of a Cod Fifh, with the lacteals and termination of the lymphatic fyftem injected with wax.

F I G. I.

1, Reprefents the eye.

2, 3, The upper and under jaws.

4, The pectoral fin.

5, The flap which covers the gills.

6, The œfophagus.

7, The ftomach.

8, The appendices cæcæ, which feem to fupply the place of the pancreas. A great number of fmall round worms were fixed to thefe appendices, and are drawn by the painter in the interftices of the appendices.

9, The beginning of the fmall inteftine.

10, 11, 12, 13, The whole tract of inteftines.

14, The anus.

15, The gall-bladder.

16, 17, The lacteals from the lowermoft part of the inteftines.

18, The lacteals from the upper part of the inteftines.

19, The large trunks which all the above-mentioned branches form.

20, Other deep-feated branches are here added.

21, Numerous lymphatics added from the gall-bladder.

22, 23, 24, Lacteals from the œfophagus.

25, The end of a trunk formed by the lacteals from the ftomach, and which is in part covered by the firft turn of the fmall gut, and then by the gall-bladder.

26, A very large receptacle of the chyle.

27, A large opening furrounded by a circular valvular membrane, which leads from the receptacle of the chyle into a very large receptacle of the lymph.

28, 29, 30, 31, Are the principal lymphatic trunks ending in the receptacle of the lymph. At their termination in the receptacle, their diameter is leffened by circular membranes, which in fome meafure have the effect of valves.

32, Is the horn of the air-bag, which paffes upwards into the receptacle of the lymph.

33, Seems to be the termination of the lacteal and lymphatic veffels, or the opening by which the chyle, after being blended with the lymph, paffes into the vena cava on this fide; but as fome part of thefe large receptacles is generally torn in catching this fifh, I found it very difficult to trace with certainty their terminations in the red veins.

34, 34, Reprefent the two venæ cavæ. From the receptacle of the chyle there are large paffages upwards to the left fide, which lead to the lymphatic receptacle on the left fide.

35, Reprefents the venæ cavæ hepaticæ.

36, The meeting of the two venæ cavæ, and the opening from them into the auricle of the heart.

37, The auricle of the heart.

38, The ventricle of the heart.

39, A bulb at the beginning of the branchial artery.

40, The branchial artery continued from that bulb.

FIG. 2.

This Figure reprefents a magnified portion of the fmall gut, mefentery, and lacteals of the Cod, injected with wax.

AA, A portion of the fmall inteftine.
BB, A portion of the mefentery.
CC, Lacteal veffels injected.
1, Small branches of lacteals anaftomofing in the gut like blood-veffels.
2, Arches which the anaftomofes of the larger veffels form.
3, Some fmall parallel lacteals are joined by crofs branches.
4, Other fmall parallel lacteals want fuch crofs joinings.
6, 7, 8, 9, In general, the large neighbouring lacteals are joined, in a very regular and fingular manner, by tranfverfe fhort fmall branches entering them at right angles.

10, 11, 12, 13, 14, There are likewife large branches, by which the large neighbouring lacteals communicate with each other.

TABLE

TABLE XXIII.

In this Table portions of the lacteal veffels of the inteftines of a Cod, injected with wax, are reprefented of their natural fize, and alfo viewed with a magnifying glafs.

Fig. 1.

A B, A portion of the fmall inteftine.

C, Its mefentery.

D, The injected lacteal veffels delineated of their natural fize.

Fig. 2.

In this figure the lacteals, delineated of their natural fize in fig. 1. are reprefented as they appear through a magnifying glafs.

F F, The net-work formed by their fmall branches.

E, A larger branch, or larger branches, in which chiefly thefe terminate: for when we examine accurately, we perceive two veffels joined together by many tranfverfe canals.

Fig. 3.

The injected lacteals in the inverted extremity of the rectum of a Cod are here reprefented.

A, The verge of the anus.

B, The inverted portion of the rectum, or its villous coat, which appears quite red from the injection filling its lacteal veffels.

C, A portion of its villous coat, in which the lacteals are delineated of their natural fize.

Fig. 4.

Shows the net-work C of fig. 3. magnified with a glafs.

TABLE XXIV.

This Table is intended to ſhow the joining of the lacteal and lymphatic veſſels in the Cod.

A, The right eye.

B C, The upper and under jaws.

D, The gill flap.

E, The undermoſt gill.

F, A bone reſembling our ſternum.

G, H, The pectoral and ventral fin.

I, A bone reſembling our clavicle, cut off from the ſternum, and turned upwards.

J, A large mucous duct.

K, The œſophagus.

L, The bottom of the ſtomach.

M, The pylorus.

N, The gall-bladder.

O, The air-bag.

P, The right cornu of the air-bag, ending in a blind ſac.

Q Q, Nerves.

R, The meeting of the two venæ cavæ at the auricle of the heart.

S, The termination of the right vena cava, which is incloſed in cellular ſubſtance, ſlit open.

T, A part of the right vena cava ſlit open, which, with the cornu P of the air-bag, and the nerves Q Q, are contained in a large and irregularly-ſhaped cavity, ſituated between the undermoſt gill and the clavicle, in which the chyle is mixed with the lymph.

U, The internal jugular vein, with a pair of valves at its termination.

V, The vein analogous to our cava inferior.

W W, The receptaculum chyli.

X X, Two openings from the receptaculum chyli into the great cavity in which the chyle and lymph are blended. The anterior opening is by much the largeſt, and has in its circumference a circular membrane or valve.

Y Y, The termination of the lymphatics from the linea recta of the abdomen, the ſternum, pericardium, ventral and thoracic fins.

Z, A paſſage by which the laſt-mentioned lymphatics communicate with the great cavity.

a a, A large lymphatic trunk, which runs on the ſide of the fiſh, and receives its branches at right angles, and terminates at *b*.

c, The termination of the lymphatics from the vertebræ, ſpinal marrow, and upper part of the head.

d, The

d, The termination of lymphatics from the under part of the head and gills.

fg h, The ends of lymphatic veffels paffing chiefly behind the heart and œfophagus, by which the right and left receptacles of the chyle and lymph communicate.

TABLE XXV.

In this Table the receptacle of the chyle and lymph in a Haddock is reprefented.

In both Figures of this Table,

A, Reprefents the mouth.
B, The noftrils.
C, The eye.
D, The anus.
E, The pectoral fin.
F, The jugular fin.
G, The lateral mucous duct.
H, The gill flap, cut at its root and turned up.
I, A red body fimilar to the human amygdala.
K, The fternum.
L, A bone refembling the clavicle.
M, A probe fupporting the gills, paffed through a natural hole.

In Fig. 1. O P Q reprefent the receptacle of the chyle and lymph inflated.

In Fig 2. The membranes O P Q of the receptacle of the chyle and lymph are cut, and the cavity of the receptacle is thereby laid fully open.

On the inner fide of the receptacle the following parts appear, covered only by the thin pellucid membrane of the receptacle, to wit, R R R, mufcles of the gills.

S, A mufcle fimilar to the human fubclavian.

T U V, The bulb of the branchial artery, the pericardium, and the left vena cava.

W, Nerves refembling thofe of our eighth pair, paffing through the receptacle to the gills.

X, A cut made in the containing parts of the middle of the abdomen a little above the anus and acrofs a principal lymphatic veffel, into which a probe is put.

The lymph conveyed by X paffes through an opening, into which a pin Y is put.

Z, A probe, ſhowing the termination of a principal lymphatic trunk on the ſide of the fiſh.

a, A probe paſſed from the receptacle of the chyle upwards into the receptacle of the chyle and lymph.

b, A portion of the receptacle on the upper ſide of the root of the gills.

TABLE XXVI.

In this Table are repreſented the heart, branchial artery, venæ cavæ, and terminations of the lymphatic ſyſtem in a Salmon.

Fig. 1.

1, The mouth.

2, The gill flap.

3, 4, 5, 6, 3, 4, 5, 6, Four pairs of gills.

7, 7, The pectoral fins.

8, The liver.

9, The gall-bladder.

10, 10, The two venæ cavæ.

11, 11, The places at which the lymphatic ſyſtem and internal jugular veins end.

12, The auricle of the heart.

13, The ventricle of the heart.

14, The bulb at the beginning of the branchial artery.

15, The trunk of the branchial artery.

16, 17, 18, 19, 16, 17, 18, 19, Four pairs of branches into which the branchial artery divides, which are ſpent on the four pairs of gills.

Fig. 2.

1, The liver.

2, 2, The two venæ cavæ.

3, 3, The right and left terminations of the lymphatic ſyſtem, which are ſimilar, contracted by membranes which perform the office of valves.

4, 4, The right and left internal jugular veins, terminating contiguous to the terminations of the lymphatic ſyſtem, and having each a pair of valves.

N. B. The terminations of the lymphatic ſyſtem, and of the internal jugular veins, appear more diſtinctly in this figure than at numbers 11, 11, of fig. 1. becauſe the orifices 11, 11, were kept on the ſtretch whilſt the painter was drawing theſe terminations.

5, 6, 7, The terminations of the venæ cavæ hepaticæ.

8, A

8, A vein which comes from the parts behind the heart.

9, The paſſage from the meeting of the cavæ into the auricle of the heart.

10, 10, The auricle of the heart.

11, The ventricle with its point turned upwards.

12, The trunk of the branchial artery ſending off its two firſt pairs of branches to the gills.

TABLE XXVII.

THIS Table repreſents in a Salmon the joining of the principal lymphatic veſſels, and the terminations of the lymphatic ſyſtem in the venæ cavæ.

A, The middle under part of the lower jaw, ſomewhat reſembling our os hyoides.

B, The ſide of the ſternum.

C, The right pectoral fin.

D, The gill flap turned back.

EFGH, The four gills.

I, An opening under the fourth gill.

K, The clavicle turned back.

L, The ſcales on the ſide of the fiſh.

MM, A large lateral lymphatic trunk ſlit open.

N, A large lymphatic covered by the inner end of the clavicle joining with M.

O, A large lymphatic from the head.

P, A receptacle of the lymph conveyed by the lymphatics MNO.

Q, A paſſage from P into another receptacle R.

S, A probe paſſed from R into the right vena cava, in which the whole ſyſtem terminates.

At the termination of the lymphatic veſſels MN and O, and at Q, the paſſages are contracted and ſurrounded with a circular membranous edge, which has in ſome degree the effect of a valve. The termination of the lymphatic ſyſtem at S is ſurrounded with a thick membrane, which ſtill more accurately performs the office of a valve.

TABLE

TABLE XXVIII.

This Table ſhows chiefly the terminations of the lymphatic ſyſtem, and the hepato-cyſtic ducts, in the Salmon.

A, The middle part of the lower jaw.
B, The gill flap.
C, The pectoral fin.
D, The diaphragm or partition between the thorax and abdomen.
E F G, The lobes of the liver.
H, The gall-bladder.
I, Hepato-cyſtic ducts opening into the neck of the gall-bladder.
K, The upper part of one of the roes.
L, A large lateral lymphatic veſſel cut open.
M N, A probe paſſed from the receptacle of the chyle and lymph into the right vena cava. The thick circular membrane, which performs the office of a valve, is ſeen diſtinctly.
O, The right vena cava.
P, The termination of the internal jugular vein.
Q, A probe paſſed from the joining of the two venæ cavæ into the auricle of the heart.
R, The ventricle of the heart.
S, The root of the branchial artery.

TABLE XXIX.

This Table repreſents chiefly, in a ſmall Salmon, the receptacle of the chyle, and the terminations of the lacteal and lymphatic veſſels in the venæ cavæ. It likewiſe ſhows the opening of the duct of the air-bag into the œſophagus.

A, The lower jaw.
B B, The gill flaps.
C C, The gills.
D, The œſophagus cut tranſverſely.
E, The lower or poſterior part of the œſophagus ſlit open.
F, A probe put into a large duct, by which the air-bag and œſophagus communicate.
G, The upper part of the left roe.
H, The gall-bladder inflated.

I K, The

IK, The lacteal veſſels from the ſtomach and inteſtines joining to form the receptacle of the chyle L, which was filled with quickſilver.

M, A plexus of lacteals, which terminate in the right vena cava.

N, Another plexus of lacteal veſſels, which run to the left ſide, behind or above the œſophagus; which was cut acroſs in order that they might be ſeen.

O, The continuation of the plexus of lacteal veſſels N, with an addition of a plexus of very large lymphatic veſſels which came from the left roe.

P, The laſt receptacle of the lymph cut open, into which the lacteal veſſels pour the chyle, or P is the chief receptacle of the chyle and lymph blended.

Q, A probe paſſed from the receptacle P into the left vena cava, ſeen by cutting it open. R, the meeting of the two venæ cavæ before they terminate in the auricle of the heart.

TABLE XXX.

In this Figure, which I publiſhed in 1770, the meſenteric artery and vein of a Sea Tortoiſe or Turtle was filled with wax, and the lacteals with quickſilver, before the drawing was made by Dr Palmer of Peterborough in 1765.

GG, Repreſents a portion of the inteſtinum ilium.

MMM, A portion of the meſentery.

AAA, &c. The branches of the meſenteric artery diſtinguiſhed by tranſverſe lines.

VVV, The branches of the meſenteric vein diſtinguiſhed by longitudinal lines.

LLL, &c. The lacteal veſſels.

PL, A plexus or net-work formed by the lacteal veſſels at the root of the meſentery.

TABLE XXXI.

FIGURE 1. Reprefents the upper part of the brain and fpinal marrow of a Haddock; and figures 2. and 3. the top of the fpinal marrow of a Cod, with the nerves iffuing from thefe, and certain fpheroidal bodies loofely connected to the brain, but clofely to the nerves.

FIG. 1.

A, The fore part of the upper jaw.

BB, Two noftrils in each fide, with probes in them.

CC, The eye-balls.

DE, Lobes or hemifpheres of the brain.

F, The hemifpheres of the cerebellum. Numerous fpheroidal bodies are flightly connected to the brain by vifcid matter between it and the cranium; others are more loofely attached to the dura mater.

G, The fpine and fpinal marrow cut tranfverfely.

I, The olfactory nerves.

K, Two fpherical cineritious bodies, with which the olfactory nerves are intimately conjoined.

LL, The branches of the olfactory nerves ending in the bottom of the nofe.

MM, A pair of large nerves refembling the fifth pair in man.

OO, Small branches are here detached towards the back part of the nofe, refembling the nafal branches of the fifth pair in man.

PP, Anterior maxillary branches of the fifth pair.

NN, The optic nerves entering the eye-balls.

Q, Spheroidal bodies attached flightly to the medulla oblongata and top of the fpinal marrow.

R, The back part of the fpine, with feveral pairs of nerves iffuing from it, covered by fpheroidal bodies firmly connected to the nerves and to each other.

HH, The pectoral fins; on one of which thefe nerves are feen dividing into fmall branches.

SS, Nerves, running lengthwife on the fides of the body, to which no fpheroidal bodies are attached.

FIG. 2.

Reprefents, in a Cod, the upper part of the fpinal marrow, of the natural fize. And fig. 3. reprefents part of fig. 2. magnified.

A, The

A, The ſpinal marrow.

B, Spheroidal bodies looſely attached to the ſpinal marrow.

C, In fig. 2. ſpheroidal bodies, covering and cloſely connected to the nerves and to each other.

Within the ſpheroidal bodies, which are tranſparent, white ſerpentine bodies are ſeen, as in fig. 3.

TABLE XXXII.

This Table repreſents the nerves of the fin of a Haddock, with ſpheroidal bodies connected to them, magnified to ſix diameters.

Fig. 1.

A B, Two nerves which join and ſeparate again, or form a plexus, which is covered by ſpheroidal bodies, adhering cloſely to it.

B, About the middle of the fin theſe ſpheroidal bodies are not contiguous to each other, but between them the pure nerve is ſeen.

C, Near the extremity of the fin, where the nerves are ſubdivided into ſmall branches, the ſpheroidal bodies are wanting.

Fig. 2.

Shows the ſpheroidal bodies ſeparated from the nerve and from each other, and magnified to ſix diameters.

They conſiſt of a tough tranſparent membrane or ſkin, containing a tranſparent viſcid liquor; in the centre of which one or two white or opaque ſerpentine bodies are lodged. Theſe ſerpentine bodies are ſeen very diſtinctly, not only when the nerve is recent, but after drying it.

Fig. 3.

Repreſents the ſpheroidal veſicles looſened a little from each other by diſſection, and magnified to ſix diameters.

TABLE

TABLE XXXIII.

Figure 1. of this Table reprefents the fpinal marrow and nerves in the tail of a fmall Haddock, diffected and magnified to four diameters.

Fig. 2. Shows the natural fize of the tail.

Fig. 1.

A, The upper, and B the under, part of the Haddock in its horizontal fituation.

CC, The bodies of the vertebræ.

DD, The fpinal marrow, with the fpinal nerves iffuing from it.

Thefe nerves, as they proceed, form plexufes GG, which are covered by fpheroidal bodies, that adhere firmly to the nerves and to each other. In the fin of the tail, the fpheroidal bodies gradually become lefs numerous; then are feen fingle, or at a diftance from each other, with the nerve appearing bare between them, as at HH, where the nerves are fupported on pins; at laft, near the edges of the fin of the tail, where the nerves are divided into fmall parts, the fpheroidal bodies are not found.

TABLE XXXIV.

In this Table are reprefented, in a Skate, the upper furface or back part of the brain and the top of the fpinal marrow, with the nerves rifing from thefe, the mufcles of the right eye, and a general view alfo of the internal parts of both ears.

A, The fnout of the fifh.

B, The eye-balls.

CCCO, The mufcles of the eye-ball.

DD, Paffages into the throat.

EFG, EFG, The femicircular canals of the ear flightly fketched.

H, A broad thin ligament which fupports the femicircular canal G.

I, The bottom of the meatus auditorius imperfectly reprefented.

J, A cavity in the fore part of the cranium filled with vifcid fluid.

KK, Two anterior lobes of the brain.

L, A middle lobe of the brain.

MM, Two pofterior lobes of the brain.

NN, Two lobes of the cerebellum.

OO, Subftances refembling our corpora olivaria.

PP, The

P P, The ſpinal marrow.

Q R, Bags containing a tough pellucid fluid, and likewiſe cretaceous matter, and which evidently reſemble our veſtible, and have alſo ſome reſemblance to the cochlea of our ear.

1, 1, 1, The olfactory nerves, much larger when they enter the noſe than where they riſe from the brain, owing to thick coats they receive in their courſe.

2, 2, The optic nerves.

3, 3, 4, Nerves reſembling our third and fourth pairs.

5, 5, 6, 6, Nerves which reſemble our fifth pair.

7, 7 Nerves which reſemble our ſeventh pair.

8, 8, Nerves reſembling our eighth pair.

9 . . . . . 28, The ſpinal nerves; each of which conſiſts of two bundles of fibres, which paſs through different holes of the dura mater.

29, 29, 30, 30, The ſpinal nerves, forming plexuſes, and appearing much larger without than within, reſembling our brachial or crural plexus.

TABLE XXXV.

The ſeveral figures of this Table repreſent the noſe, mouth, ear, and larynx of a Porpeſs *.

Fig. 1.

A B, Repreſent the two jaws and mouth.
C, A ſmall portion of the right pectoral fin.
D, The entry into the noſe or ſpiraculum.
E, The eye.
F, The entry to the meatus auditorius externus.

Fig. 2.

Repreſents the lips or entry to the ſpiraculum.

A, The anterior, and B the poſterior, lip.

Fig. 3.

Shows the ſpiraculum and noſe cut open on the right ſide.

A, A probe introduced into the ſpiraculum.
B, Its inner membrane, of a black colour, with a number of folds or valves.

* Lin. Syſt. Nat. Cete; Delphinus; Phocæna.

C, A frænum fixed above a chink between two ligamento-cartilaginous bodies D and E. Thefe bodies refemble the human epiglottis, and the frænum is like the membrane which ties the epiglottis to the tongue.

F G, Two large facs feparated from each other by the frænum. The right fac is laid open, and a probe is paffed into the left one. The membrane lining thefe facs is of the fame colour, and has the fame kind of folds or valves, as were feen at B. Thefe facs conftitute the organ of fmell.

H, A thimble-like cavity, lined with a thin fmooth membrane, under the right fide of the epiglottis, or rather under the right epiglottis.

I K, Probes paffed into the right and left noftrils or air-paffages, which are divided from each other by a feptum L.

FIG. 4.

THIS Figure fhows the continuation of the fpiraculum or air-paffage and the larynx, after cutting open the mouth and throat on the right fide, and inverting the head.

A, The edges of the tongue ferrated.

B, The upper furface of the tongue.

C, The top of the larynx; the upper part of which confifts of one cartilage, but the under part is compofed of two cartilages.

D, A mufcle for fhutting the top of the larynx.

E F, Two mufcles for opening the larynx.

G, The right fide of the larynx is cut into, to fhow G, a ligament in the middle of its under part.

H, The termination of the fpiraculum, over the mouth of the larynx, furrounded by a mufcle I.

K, The right fide of the fpiraculum cut open, to fhow the back part of the feptum K.

L M, The lower ends of the two probes, feen in fig. 3. at I K.

N, A cylindrical tube from K to H.

O, A probe put into the mouth of the right Euftachian tube, or iter à palato ad aurem.

FIG. 5.

THIS Figure fhows the outfide of the os petrofum, with the meatus auditorius externus and the Euftachian tube laid open their whole length.

F, The entry to the meatus auditorius externus.

G, The meatus auditorius externus laid open its whole length, and crooked at its back part G.

H, The

H, The outſide of the os petroſum; the point of which, H, reſembles our maſtoid proceſs.

I, The membrane of the drum, concave on the outer ſide.

K, The right noſtril cut farther open, to ſhow L, the mouth of the Euſtachian tube.

M, The Euſtachian tube laid open from its origin to its termination within the ear or os petroſum at N. It is gradually enlarged in its courſe from the noſe to the ear.

FIG. 6.

THE inner ſide of the os petroſum H, and of the adjoining bones being cut away this figure repreſents the cavity of the tympanum, its contents, and the parts with which it communicates.

I, The bottom of the meatus auditorius externus, and membrana tympani concave on the outer ſide.

K L, A red-coloured ſubſtance and chain of ſmall bones, by which the membrane of the drum is drawn inwards, and connected to the bottom of the cavity of the tympanum.

M, A ſmall muſcle fixed to the laſt of the ſmall bones, reſembling our ſtapes and its muſcle.

N, A probe paſſed from the Euſtachian tube into the cavity of the tympanum.

O, A ſubſtance within the os petroſum or cavity of the tympanum, which in ſhape reſembles our os ſpongioſum inferius.

P, A large paſſage leading from the cavity of the tympanum forwards to caverns Q and R; the latter of which leads to the frontal ſinus.

FIG. 7.

Repreſents the inner ſide of the os petroſum S, with the auditory nerve T entering it.

FIG. 8.

Repreſents the inner part of the os petroſum; from which the auditory nerve and part of the ſubſtance of the bone are cut off, in order to ſhow the holes by which the nerves enter, and part of the cochlea and ſemicircular canals.

S, The inner ſide of the os petroſum.

UV, The holes by which the branches of the auditory nerve enter.

W, A ſmall portion of the cochlea cut open.

X, One of the ſemicircular canals cut open.

FIG.

FIG. 9.

Shows the cochlea further cut open.

W, A tube which fills one of the ſcalæ of the cochlea.
Y, Part of the ſeptum between the ſcalæ of the cochlea.
Z, The ſecond turn of the cochlea cut perpendicularly in two places.

TABLE XXXVI.

THE ſeveral figures of this Table repreſent the organ of hearing of the Sea Tortoiſe or Turtle.

FIG. 1.

IN this Figure the roof of the mouth is delineated, with the mouths of the Euſtachian tubes of the ears.

A B C, The teeth of the upper jaw.
D E, The condyles with which the lower jaw is articulated.
F G, The holes by which the cavities of the noſe communicate with the mouth.
H I, Probes put into the Euſtachian tubes of the ears.
K, Part of the right Euſtachian tube cut open.

In Figures 2. and 3. the upper part of the organ of hearing is repreſented.

FIG. 2.

A, Repreſents the hollow outer part of the head, on the right ſide, analogous to our right temple.

B, A large cavity within this place laid open by a horizontal ſection.

C, The termination of the Euſtachian tube in that cavity, ſhown by a probe introduced into it.

D, A white tendinous-looking ſubſtance, which connects the hollow part of the temple to the inner part of that cavity.

E, The outer end of a long cartilaginous body, which, like the oſſeo-cartilaginous ſubſtance in birds, ſeems to ſupply the place of the malleus, incus, os orbiculare, and ſtapes, in man; or which connects the hollow part of the temple to the labyrinth of the ear.

FIG.

FIG. 3.

A, A thin plate of cartilage, which is found on the inner fide of the temple.

B, The cavity in which the Euftachian tube terminates laid open.

D, The tendinous-like fubftance which connects the temple to the inner fide of that cavity.

F, The outer end, and F the inner end, of the long cartilaginous body, which connects the temple to the labyrinth of the ear, having its inner part F connected to a membrane refembling that of our feneftra ovalis.

G H I, Three femicircular canals, to wit, an anterior, a pofterior, and a middle horizontal canal.

In FIG. 4.

The organ of hearing is feen from below.

A, Reprefents the right condyle for the articulation with the lower jaw.

B, The under part of the inner end of the cartilaginous body, which connects the fkin of the temple to the membrane of the feneftra ovalis, or to the labyrinth of the ear.

C, A fac which contains a foft cretaceous matter, like to that found in the ear of a fkate fifh.

D, Nerves refembling the portio mollis of our feventh pair, ending on this fac.

TABLE XXXVII.

In this Table are reprefented, in a Skate, the bafis of the brain, cerebellum, and top of the fpinal marrow, with the nerves coming out from thefe; and the different parts of the ear are likewife accurately fhown.

FIG. 1.

1, 1, The nofe.

2, The cavity in the fore part of the cranium, which is filled with vifcid fluid.

3, 3, The anterior lobes of the brain.

4, 4, Two fmaller lobes behind thefe.

5, A round lobe compofed of vafcular and cineritious fubftance.

6, 6, Medullary lobes under the lobes of the cerebellum.

7, 8, Medulla oblongata and medulla fpinalis.

9, The uppermoſt branchial vein.

10, 11, 12, An artery continued from the uppermoſt branchial vein, which ſupplies the noſe and external part of the head.

13, A bundle of ſmall arteries from branch 12th, which run upwards to the brain.

14, 15, 16, 17, 18, 19, Veins from the ſecond and third gill, which ſend off,

20, 21, The principal artery of the brain, cerebellum, and top of the ſpinal marrow.

23, The olfactory nerve.

24, 24, The two optic nerves.

25, 25, 26, 26, Nerves reſembling our third and fourth pairs.

27, 27, Large nerves reſembling our fifth pair.

28, A large branch of 27 entering the orbit.

29, A branch of 27 paſſing within the cartilages, which contain the parts of the internal ear.

30, A ſmall twig of 27 loſt on a ſmall bag of the ear, which contains cretaceous matter.

31, Another twig of 27 loſt in a bulb or enlarged part of the anterior ſemicircular canal of the ear.

32, A large branch from 27, which paſſes onwards on the fore part of the cartilage incloſing the ear.

33, A twig from 27 to the bulb of the middle ſemicircular canal of the ear, or horizontal canal.

34, Part of a large branch of 27 adhering to and loſt in the large bag which contains cretaceous matter.

35, A nerve ſomewhat like to our ſeventh pair.

36, A nerve ſent to the large bag which contains cretaceous matter, from the joining of 27 with 35.

37, Another branch from the joining of 27 with 35, loſt on the bulb of the poſterior perpendicular ſemicircular canal of the ear.

N. B. As ſoon as the nerves reach the bulb of the ſemicircular canals, they become pellucid, and are loſt.

38, 39, The remainder of the branch formed by the joining of 27 and 35 paſſes through the cartilage at the back of the ear, to be diſperſed on the external parts, and may perhaps be compared to our portio dura of the ſeventh pair.

40, A briſtle entered from the meatus auditorius externus into the internal ear.

41, A branch of 35, which runs upwards.

42, 42, Large nerves, which have ſome reſemblance to our eighth pair.

43, 44, 45, 46, 47, 48, Nerves reſembling our ſub-occipital and cervical nerves. The anterior and poſterior bundles which compoſe theſe nerves paſs through different holes of the dura mater.

FIG.

Fig. 2.

1, 2, 3, 4. Reprefent the thicknefs and fhape of the cartilages which inclofe the internal ear.

5, The anterior femicircular canal of the ear.

6, A dilatation or bulb in that canal.

8, 9, The middle or horizontal femicircular canal and its bulb, to which a bit of its nerve adheres. Near to their bulbs thefe two femicircular canals join together, fo that they have but three ends; in this refpect refembling the femicircular canals of our ear.

10, 11, 12, The pofterior femicircular canal.

13, A flat aponeurofis, ftretched between the upper part of the pofterior femicircular canal and the pofterior part of the horizontal or middle canal.

14, The great bag that contained the cretaceous matter cut open, and the chalk taken out of it; or it is reprefented empty and collapfed.

15, A fmall bag, or appendix to the large bag, which likewife contains chalk.

16, 17, The meatus auditorius with a briftle in it, laid open its whole length. 16, Shows the external opening, and a larger cavity or concha within it. 17, Shows a narrow paffage between cartilages, refembling the deep offeous part of our meatus auditorius.

18, Reprefents the briftle entering the large fac which contains the chalk. No Euftachian tube is found here, one paffage fupplying the place of both external and internal meatus auditorius of man.

Behind the concha there is a large foft part, which is fhown by a pin ftuck through it.

Fig. 3.

This Figure reprefents the communication of the external meatus auditorius of a Skate with the large fac which contains cretaceous matter; and the communication of the large fac with a fmaller, and with the femicircular canals, feen obliquely from the inferior fide.

a, A briftle paffed from the concha of the external ear, through the meatus auditorius externus, into *b*, a large pyramidal fac, which contains a vifcid pellucid humour, with a regularly-fhaped cretaceous fubftance, and feems to fupply the place of our veftible.

c, An oblong opening is found, at a dotted line here, by means of which the large fac communicates with a fmall fac *d*, which likewife contains cretaceous matter and a vifcid humour, and is fituated on the upper or fore part of the large fac.

e, A canal leading from *d* into *f*.

f, A

f, A canal common to the horizontal ſemicircular canal *g*, and the ſuperior or anterior ſemicircular canal *h*.

i, The place at which the canals *e f g* and *h* meet and communicate.

k, A canal from the poſterior part of the great ſac, which communicates with *l*, the uppermoſt end of the inferior or poſterior ſemicircular canal *l m*. Hence *k l m* communicate with each other at *n*.

o o o, The cartilaginous ſubſtance which contains the ſemicircular canals and cochlea.

p p, Two ligaments, over which the ſuperior and inferior, or anterior and poſterior, ſemicircular canals paſs.

FIG. 4.

Repreſents the ſemicircular canals of the ear and bags, which reſemble our veſtible, or perhaps cochlea and veſtible, with their nerves, ſeen from their under part, in a very large Skate.

A B C D E F, Repreſent the cartilage which incloſes the ear.

27, 29, 30, 31, 33, 34, 35, 36, 37, 38, Repreſent the ſame parts as in fig. 1. but more accurately, and in a much larger ſkate.

a, Repreſents a ſmall bag which projects from the large bag.

b c d e f, Repreſent a cellular texture filled with fluid, which connects the ſacs and ſemicircular canals with the membrane which lines the cartilage, and conducts nerves from the ſacs and ſemicircular canals to that membrane. Veſſels conveying red blood are likewiſe diſperſed upon it and lymphatic abſorbents; a great number of which I have injected.

TABLE XXXVIII.

THIS Table repreſents the upper or back part of the head, and the ſtructure of the ear, of the Squalus Squatina or Angel Fiſh.

A, The mouth.

B B, The noſe.

C C, The eyes.

D D, The paſſages into the gills.

E E, The roots of the muſcular flaps, which are compared to wings.

F, The place at which the head is articulated with the ſpine.

G, A ſmall ſpace of the occiput between the meatus auditorii externi HH, into the right one of which a briſtle is introduced.

I, A ſmall gutter marked in the external ſurface of the ſkin, and running obliquely forwards and inwards from the meatus auditorius externus.

K, Is

K, Is placed over the feptum which feparates from each other two cavities, which may be compared to our conchæ auris.

L, A briftle paffed from the concha auris into the continuation of the meatus auditorius externus, and from it into M, a fac which contains a foft body compofed of cretaceous matter.

N O P, Three femicircular canals, which communicate with each other and with the fac M.

Q, A tendinous fubftance, which happened to be laid in view in diffecting the ear.

TABLE XXXIX.

In this Table the optic nerves and parts of the ear of a Cod are reprefented. In fig. 1. and 4. fimilar parts are pointed out by the fame letters; fo that one explanation may ferve for both.

A A, The fore or under part or bodies of the vertebræ.

B, The fore part of the cranium.

C C D, Tubercles of the brain.

E, The root of the optic nerves where they are conjoined.

F, The right optic nerve paffing over the left one G.

H H, The two eye-balls.

I, The left fac which contains the principal ftone of the ear, with a large nerve elegantly ramified upon it.

K, The point at which three femicircular canals of the ear meet, and communicate with each other.

L, The joining of the fuperior or anterior femicircular canal M with N the middle horizontal femicircular canal.

O, The inferior or pofterior femicircular canal.

P, The joining of the horizontal canal with the pofterior.

Q, The trunk of the auditory nerve.

R, A branch from it to the capfule of the large ftone.

S, Another branch from it, which fends branches to join R and other branches to the femicircular canals.

T, Small nerves from the fame nerve Q are difperfed, with minute blood-veffels, upon membranes and a vifcid matter which fills the fpace between the femicircular canals. Some of the nervous threads are fixed to minute fpheroidal bodies difperfed in this vifcid matter, and which refemble bodies found on the outfide of the brain, and alfo adhering to moft of the nerves.

V, A fmall bag which contains vifcid matter and receives a nerve, which feems to make a part of the organ of hearing.

F I G. 2.

Shows the large ſtone of the ear taken out of its ſac.

F I G. 3.

Shows one of the ſmall ſtones of the ear taken out of the dilated portion, where the anterior ſemicircular canal joins with the horizontal one.

F I G. 5.

Shows the ſituation of the ſemicircular canals and large ſtone of the ear, with reſpect to each other and to the brain, after cutting off the upper part of the cranium.

A B, The lobes of the brain ſeen on their upper part.

C, The cerebellum.

D, The ſpinal marrow.

E, A branch of nerves, which reſemble our fifth pair.

F G, A perpendicular canal, connecting, or common to, the ſuperior and inferior ſemicircular canals of the ear.

H, The ſuperior, and I the inferior, ſemicircular canal. At this place they receive branches from nerves which reſemble our fifth and ſeventh pairs.

K, The upper part of the ſac which contains the large ſtone of the ear.

L, A nerve which reſembles our ſeventh nerve, and likewiſe in a great meaſure ſupplies the place of our eighth.

TABLE

TABLE XL.

FIGURES 1. and 2. of this Table reprefent the nofe; and figures 3. and 4. the ear of a Sturgeon.

FIG. 1.

Reprefents the nofe on the right fide, as it appears without diffection.

A, The upper and anterior opening into the nofe.
B, The under and pofterior opening.
C, An intermediate covering of the nofe.

In FIG. 2.

The letters A and B are oppofed to the natural openings into the nofe.
C, The intermediate covering is cut and turned forwards.
D, The nofe is fully feen, confifting of nineteen doublings of membranes of unequal length, which, like radii, iffue from one centre.

FIG. 3.

Reprefents the outer fide of the three femicircular canals of the right ear, laid in view by diffection.

AB, The anterior femicircular canal, in which there is a dilated portion at B,
CD, The pofterior femicircular canal.
EF, The horizontal femicircular canal, in which there is a dilated part at E.

FIG. 4.

Reprefents the joining of the three femicircular canals on the inner fide, or fide next to the brain, and their communication with a large fac containing a ftone.

AB, The anterior femicircular canal, and B its dilated part.
CD, The pofterior femicircular canal, and D its dilated part.
EF, The horizontal femicircular canal, and E its dilated part.

G,

G, A large common canal or veſtible, by which the three ſemicircular canals communicate.

H, A bag which communicates with the veſtible at I.

K, A ſtone taken out of the bag H, repreſented of its natural ſize, and likewiſe magnified.

TABLE XL*.

Fig. 1.

This Figure repreſents an horizontal ſection of the cryſtalline lenſes of an Ox and of a Cod enlarged to four diameters; one-tenth part of an inch in the figure repreſenting one-fortieth part of an inch in theſe lenſes.

ABCD, The lens of the Cod.

E, The middle of the greateſt diameter of the lenſes.

FA, The radius of the anterior part of the lens of the cod BAC.

N.B. F ſhould have been placed at the twentieth of an inch from E.

ED, The radius of the poſterior convexity of the lens of the cod.

IL, The greateſt tranſverſe diameter of the lens of the ox.

IKL, The anterior convexity of the lens of the ox.

GK, The radius by which the anterior convexity of the lens of the ox was deſcribed.

IML, The poſterior convexity of the lens of the ox.

HM, The radius of the poſterior convexity of the lens of the ox.

I*k*L*m*, A dotted figure, repreſenting the ſection of a lens of the breadth of that of the ox, and deſcribed with ſuch radii as Dr Petit aſſigns to the ſpheres which compoſe the lens of the ox.

Fig. 2.

ABCD, Repreſents the ſection of a hollow ſphere of glaſs, *d* its centre.

F, The focus of parallel rays of light, after being tranſmitted through ſuch a ſphere filled with water.

A*bcd*, A lens, formed of the anterior and poſterior portions of the ſame hollow ſphere; the length of the axis of which is equal to the radius of the ſphere.

D, The focus of parallel rays, after they have paſſed through ſuch a lens filled with water.

A*idk*, The ſection of a lens; the breadth of which is exactly equal to the diame-

diameter of the ſphere A B C D, and its thickneſs or length of its axis equal to the radius of the ſphere.

g d and *h* A, The radii by which the ſection of this lens was deſcribed.

3. The focus of parallel rays, after paſſing through ſuch a lens filled with water.

Hence the focus of ſuch a lens is nearer to the fore part of it than the focus of the ſphere is to its fore part by the length 3 F; and the focus D of the lens A *b d e* is only a diameter of the ſphere A B C D diſtant from its fore part: whereas the focus of the ſphere itſelf is diſtant from its fore part A a diameter and a half *.

TABLE XLI.

In this and in the next Table, the ſtructure of the Sepia Loligo is repreſented.

FIG. 1.

A A, The tail of a triangular ſhape.
B B, A hollow muſcular ſheath, which incloſes the body, cut open.
C, A fleſhy funnel, with its conical point turned forwards.
D D D, &c. Ten fleſhy arms ſurrounding its mouth.
E, A few cups painted, of which there are many on each arm.
F, The mouth, which has a beak reſembling that of a parrot.
G, Part of the œſophagus.
H, The ſtomach.
I, Part of the upper end of the inteſtinal canal.
K K, The rectum and anus.
L L, A cluſter of glandular-like bodies, which probably is the ovarium.
M M, A very large liver.
N, The ink-bag.

* In Chapter XI. I alleged that the veſſels of the iris in man and quadrupeds are not lymphatic, as Dr Ferrein and Dr Haller have taught, but convey red blood. In full confirmation of which, I would here add, that in the iris of the living white rabbit, where the pigment is wanting as well as in their choroid coat, I have ſeen with the naked eye, and ſtill more diſtinctly with a magnifying glaſs, numerous veſſels full of red blood.

If it ſhall ſeem neceſſary to have ſtill clearer proof than was given in Ch. XI. of the inaccuracy of Dr Petit's Table, of the breadth, thickneſs, and radii of the human cryſtalline lens, as well as of that of the ox, I would obſerve, That the breadth and thickneſs of N° 1. 2. 8. 13. 17. 18. 21. of that Table are ſaid to be the ſame; yet both radii of N° 21. are repreſented as greatly longer than thoſe of the other numbers. In like manner, both radii of N° 1. are longer than in N° 2. and the radius of the anterior convexity of the lens in N° 1. is longer than that of N° 13. 17. 18; while the radius of the poſterior convexity is the ſame in all theſe. But it is demonſtrable, and indeed at firſt ſight evident, that if the breadth of lenſes, compoſed of portions of different ſpheres, be the ſame, their thickneſs muſt vary according to the radii of thoſe ſpheres.

O, A duct from the ink-bag runs between the liver and rectum, in which it terminates near the anus, where, at K, a probe is introduced.

P, The back part of a thin coated large ſac, which ſeems to be the urinary bladder.

Q Q, The two branchiæ, gills or lungs.

R, The anterior vena cava, which receives blood from the head and arms at S, and from the liver at T. Veins likewiſe join it from the ſtomach and inteſtines U U, and upper back parts of the muſcular ſheath V V.

W W, The anterior vena cava dividing into two equal branches.

X X, Two poſterior venæ cavæ.

Y Y, Two auricles, one on each ſide.

Z Z, Two ventricles correſponding with the auricles.

a a, *a a*, Two branchial or pulmonary arteries.

FIG. 2.

R, W W, X X, Y, Z Z, *a*, Repreſent the ſame parts as in Fig. 1. On the left ſide, the ventricle L and the branchial artery *a* are ſlit open.

b, Repreſents the opening from the auricle Y into the ventricle Z.

e, A valve at that opening.

d, Three ſemilunar valves at the beginning of the branchial artery.

FIG. 1.

e e, *e e*, Two branchial veins.

g, A third ventricle, in which the branchial veins terminate.

h, The anterior or aſcending aorta.

i, The poſterior or deſcending aorta, which is much ſmaller than the anterior.

FIG. 2.

In this Figure the third ventricle and the aortæ are ſlit open.

k k, A pair of valves, where each of the branchial veins terminates in this ventricle.

h i, The aortæ ſlit open.

l l, Valves at the beginning of both aortæ.

FIG. 1.

m, The anterior aorta runs up to the muſcles of the back bone, the arms, head, &c.

n, Bran-

n, Branches to the alimentary canal.

op, Branches from the poſterior aorta, which run to the branchial hearts and ink-bag.

rq, The poſterior aorta running along a membranous ſeptum towards the under and poſterior part of the muſcular ſheath and tail.

FIG. 3.

DD, &c. The roots of the arms.

GG, A probe paſſed into the œſophagus and out at the beak.

v, An organ which ſeems analogous to the brain.

yy, The optic nerves.

xx, Organs of a firmer texture than *v*.

z, A bulb in texture ſimilar to *v*, which perhaps reſembles a hemiſphere of the cerebellum; for on the other ſide there is a ſimilar knob.

x, A thread produced from *z*, analogous perhaps to the ſpinal marrow.

t, A hard plate by which the cryſtalline lens is firmly connected to the cornea.

v, A ſubſtance ſofter than that of the cryſtalline lens, in which the lens is lodged.

TABLE XLII.

THIS Table is chiefly intended to repreſent the organs of generation and urine of the Sepia.

AB, Part of the muſcular ſheath.

C, The inner muſcular funnel.

D, The liver.

E, The rectum.

F, The right gill or lung.

GH, The right and left branchial veins.

I, The third heart, in which theſe veins terminate.

KL, The aſcending and deſcending aorta.

MN, The organ of generation, through which, at M, the turns of the alimentary canal appear.

O, The end of the duct from the organ of generation.

At the ſide of the large figure is delineated, of the natural ſize, and alſo magnified, one of the bodies which on preſſure is diſcharged from the organ of generation.

P, A

P, A large organ, ſuppoſed to be the kidney; from which a duct, Q, ſeems to come out, to terminate in a large bag S, ſuppoſed to be the urinary bladder.

At the upper part of the Table is delineated, of the natural ſize and magnified, a ſtone, ſuppoſed to make part of the ear of the ſepia.

TABLE XLIII.

In this and in the following Table, the parts of the Sea Egg or Echinus Marinus Eſculentus are repreſented.

The two Figures of this Table repreſent chiefly the ſockets of the teeth, the alimentary canal and roe of the Echinus, with their circulating veſſels injected with quickſilver.

In Fig. 1. and 2.

ABC, Thorns or feet on the edges of the ſhell; the middle part of which is cut away, in order to ſhow its cavity, and the turns of the alimentary canal.

D, A circle from which the muſcles of the teeth E take their riſe.

F, The œſophagus.

G, A turn of the œſophagus, which is tied by a ligament to the oppoſite ſide of the ſhell near the anus, as is repreſented at G in Fig. 2.

H, The œſophagus terminating in the ſide of the inteſtine.

IKLM, The firſt waving circle the inteſtine and meſentery deſcribe.

NOP, A ſecond or reverſed circle theſe deſcribe.

Q, The inteſtine cut away from the anus. Its termination is ſeen at Q in Fig. 2.

Two veſſels filled with quickſilver are delineated, almoſt contiguous, running along the meſentery from H to P.

RSTUV, In both figures repreſent five internal ducts, which receive fluids from vaſcular plexus placed on the inner ſide of the ſhell.

XYZ, In Fig. 2. repreſents the roe ſubdivided into five lobes.

TABLE XLIV.

Seventeen figures of this Table reprefent the origin, courfe, and termination of the abforbent veffels of the Sea Egg or Echinus. The four laft figures reprefent certain moveable organs articulated with the outer fide of the fhell, in the interftices of the thorns.

Fig. 1.

Reprefents a part of the outer fide, And,

Fig. 2.

Part of the inner fide of the fhell pierced with a pair of rows or phalanges of holes, into which briftles are introduced, which are marked with the fame figures or letters on both fides of the fhell.

Fig. 3.

A, The mouth of the echinus with five teeth.

B, The outfide of the fhell, to which the fockets of the teeth are connected by a ftrong membrane.

CD, One row or phalanx of open-mouthed abforbent tubes, which lead to the holes delineated in Figures 1. and 2.

EF, Some of the thorns, which ferve as feet, delineated.

Fig. 4.

B, The outer fide of the fhell.

CD, Some of the abforbent veffels dried after filling them with quickfilver.

Fig. 5.

One of the abforbent veffels in its collapfed ftate, viewed through a magnifying glafs, which enlarges it to five diameters, after flitting open the root of it, and introducing a couple of briftles into it, and into the holes which lead from it through the fhell.

Fig. 6.7.8.

The perforated plates on the mouths of the abforbent veffels, viewed with the fame glafs.

AAA, A tough and firm, jointed plate, perforated in its middle, and ferrated at its edges like the wheel of a watch.

BB, The hole in it, into which, in Fig. 7. a briftle is introduced.

CC, Circular mufcular fibres which compofe the abforbent veffel.

FIG. 9.

Shows the appearance thefe abforbent veffels make when they fix themfelves to the inner fide of a glafs veffel.

A, The glafs veffel fuppofed to contain the animal.

B, Some of the thorns.

CD, The abforbent veffels bended in various directions, with the perforated plate at the beginning of thefe veffels applied flat to the glafs.

FIG. 10.

One of the fame veffels viewed with a magnifying glafs.

A, The glafs veffel.

B, The fide of the abforbent veffel.

C, The plate at the beginning of it, with the hole appearing in its centre.

FIG. 11. and 12.

Show, with the fame magnifying glafs, the abforbent veffels as they appear when the animal elongates them in water. On their upper and under fides two fmall fafciculi of longitudinal mufcular fibres are feen, which were overlooked by the painter in the former figures. The circular fibres are feen within and between thefe fafciculi.

The flefhy part of the abforbent contracts to a fmaller diameter than that of the plate at its beginning.

The plate is pufhed out into a conical form; and the hole in its centre is fcarcely diftinguifhable.

The abforbent tubes, acting in the manner reprefented, become above an inch and a half long; or, with the magnifying glafs employed, appear to be above feven inches long. Hence the end of them alone is reprefented.

FIG. 13.

Reprefents the inner fide of the fockets of the teeth and jaw, and part of the inner fide of the fhell, with the continuation of the abforbent veffels; the plexus they form on doubled membranes within the fhell; and their whole courfe and termination in the fockets of the teeth.

A,

A A, A circular plate from which mufcles are fent to B B, the roots and fockets of the teeth.

C, A fection of the œfophagus.

D E, Two rows of leaves or doubled membranes connected to the inner fide of the fhell. On thefe membranes the abforbent veffels, after piercing the fhell, divide into a plexus of veffels, which communicate freely with each other; and which are here delineated of their natural fize when filled with quickfilver.

F, A large ftraight veffel, which receives at a right angle a branch from every plexus. There are nearly, if not exactly, the fame number of plexus or of fuch branches as of external abforbent veffels. The veffel F, after paffing through a large hole or arch in the circular plate A A, divides into two branches, which terminate in round facs G G G G G, which are placed over large cavities in the fockets of the teeth.

Fig. 14. and 15.

Reprefent two of the leaves or doubled membranes with their plexus of veffels filled with quickfilver, viewed with the magnifying glafs.

A B, Two branches from different external abforbent veffels, after piercing the fhell, entering the fame plexus.

C, The veffels of the plexus communicating freely with each other.

A B D E F, A veffel which may be traced in a circle on the outer edge of the plexus.

F G, The duct conveying the liquor from the plexus to the common duct H, which was reprefented at F in Fig. 13. and at R S T U V in Tab. XLIII. Fig. 1. and 2.

Fig. 16.

Shows one of the teeth with its focket, which is cavernous, and through it a briftle is paffed.

Fig. 17.

Shows three of the teeth with their fockets A A, BB, C. On their inner fide the œfophagus D is reprefented flit open.

A briftle E E is paffed from one of the round facs G G G G G, reprefented in Fig. 13. through the cavity of the focket of one of the teeth, and is brought out between the beginning of the œfophagus and the fide of the tooth.

FIG. 18. 19. 20. 21.

Reprefent parts which are difperfed over the outfide of the fhell in the interftices of the thorns or feet. They are articulated with it by mufcular ligaments, and fupported on folid cretaceous foot-ftalks. Beyond the foot-ftalks thefe bodies are foft and moveable; and at their points fome cretaceous particles are intermixed with the foft parts.

There are three varieties of thefe bodies. Two of the varieties agree nearly in fhape, but differ in fize.

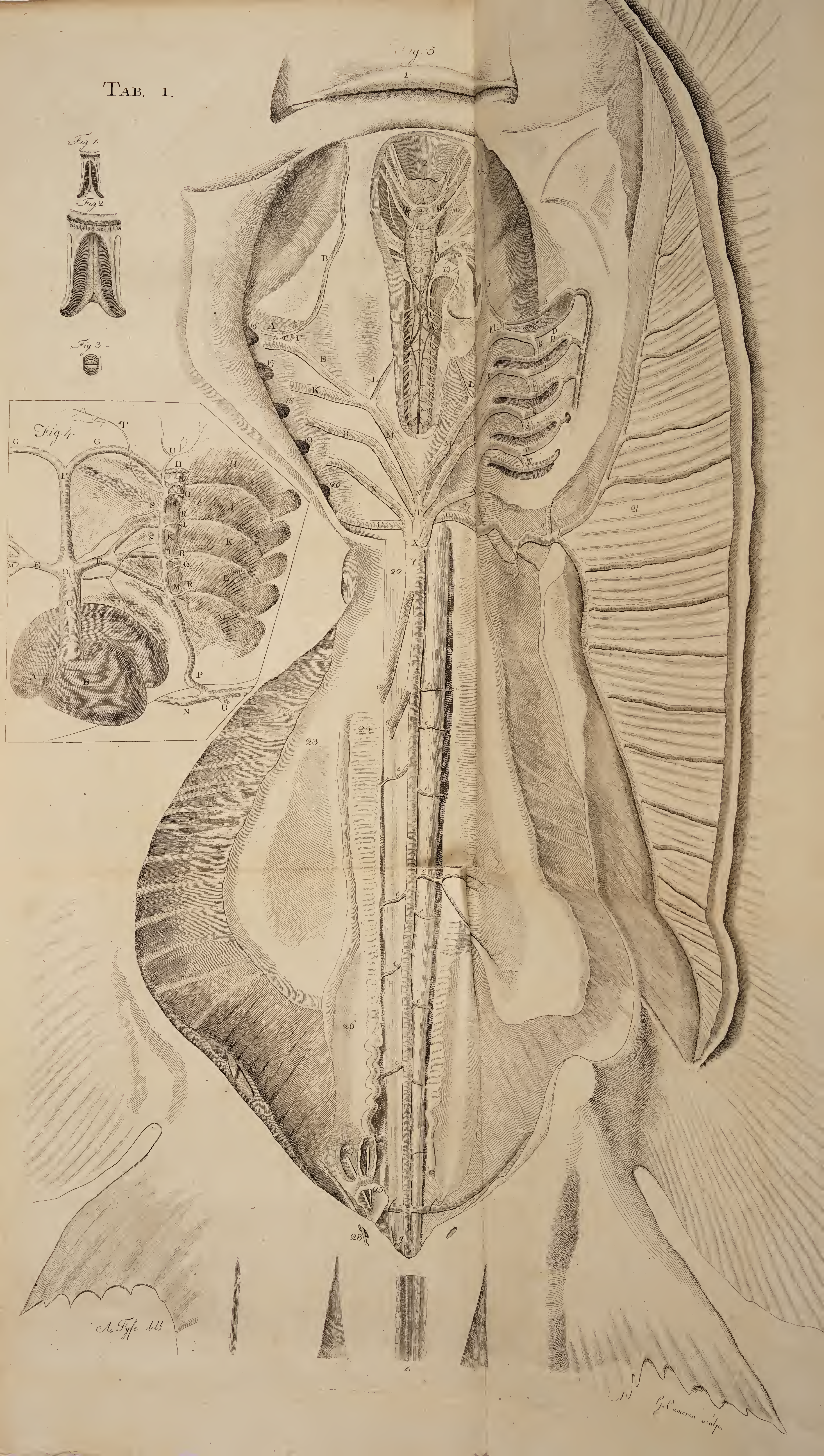
In FIG. 18.

A B, Reprefent the thorns or feet. CDE reprefent the three varieties of thefe moving bodies.

FIG. 19. 20. 21.

Show the fame bodies apart; and they are magnified to about two diameters in all thefe figures.

FINIS.



Tab. 1.
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig 5
A. Fyfe del.
G. Cameron sculp.

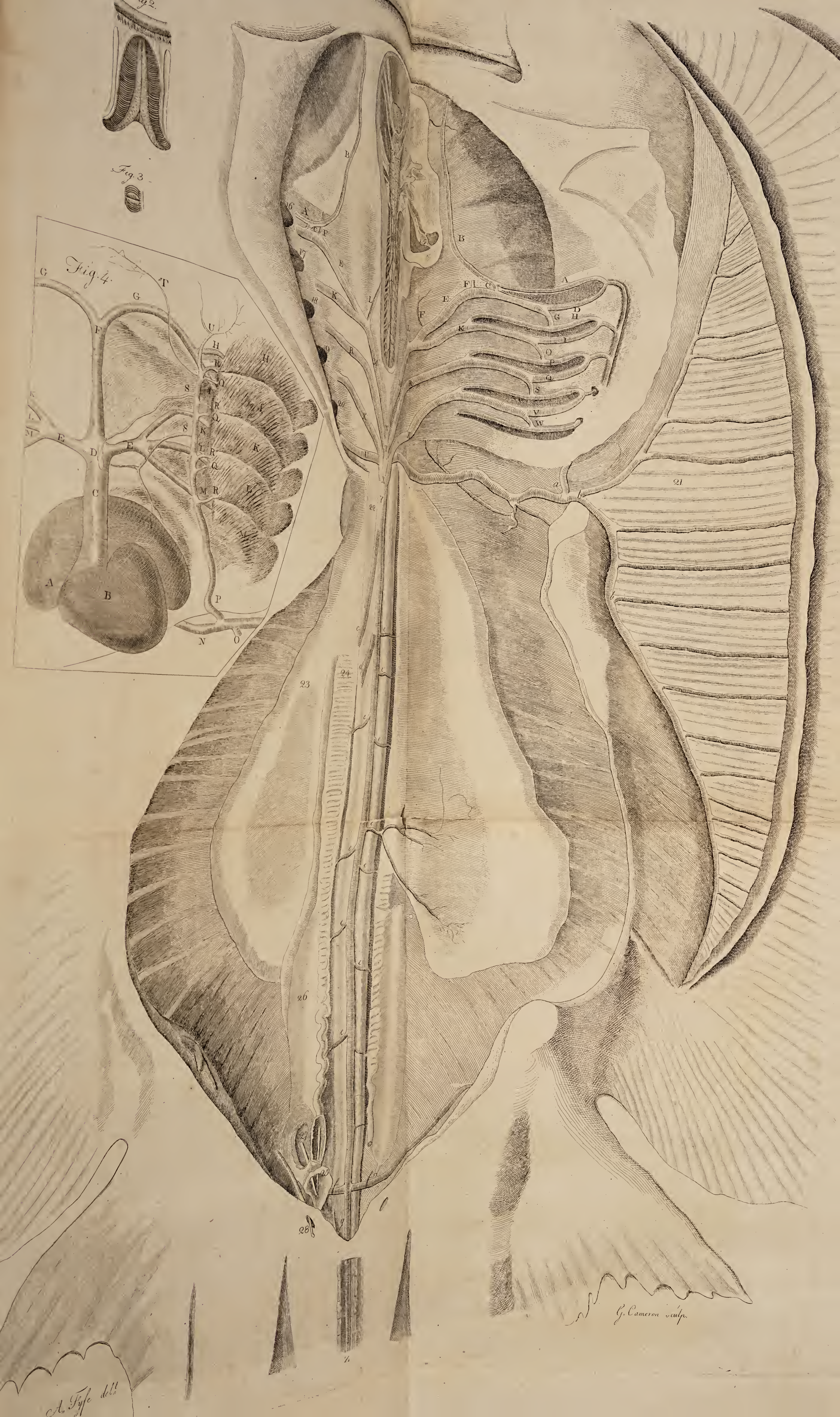
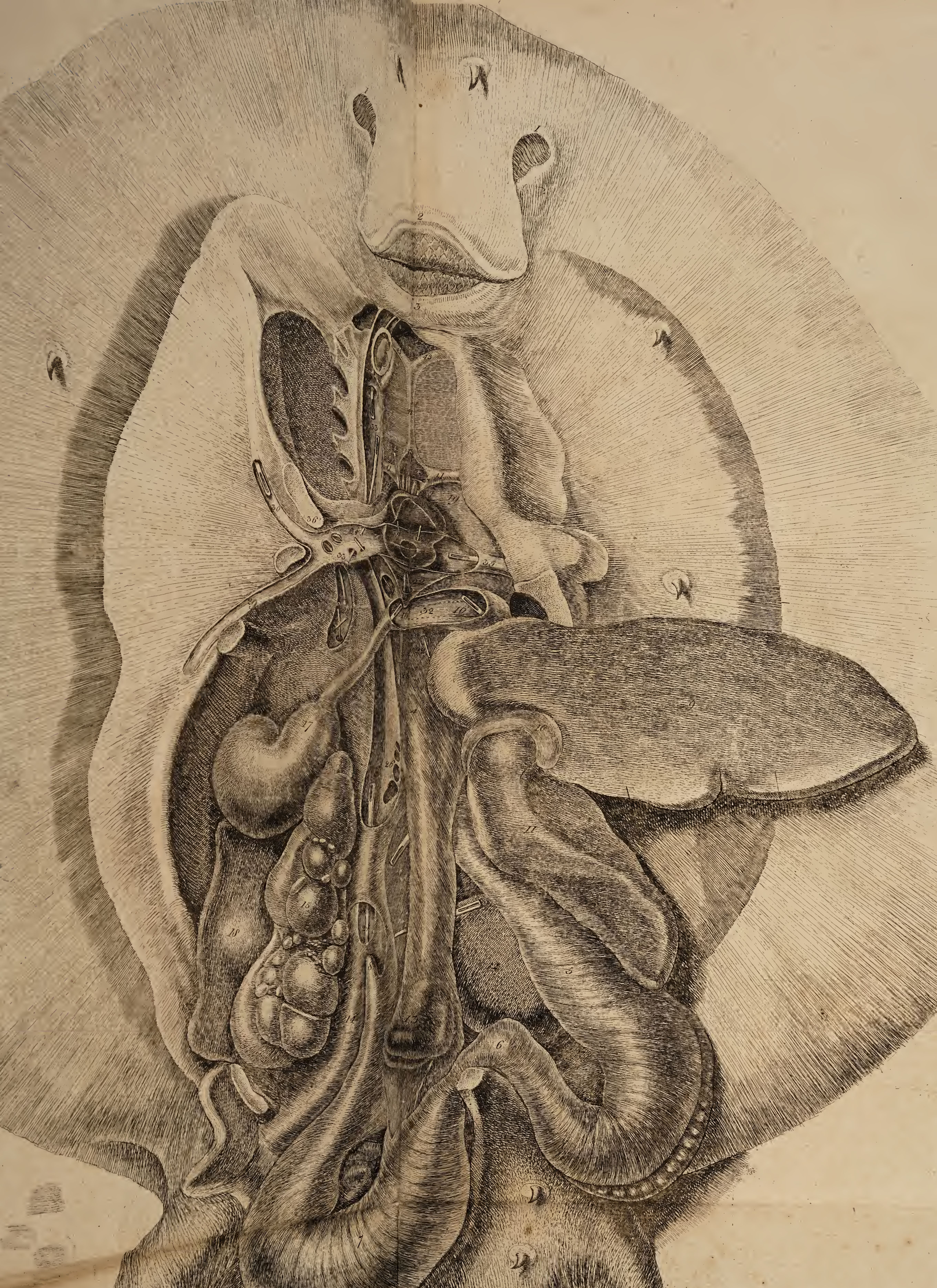


Fig. 3
Fig. 4
G. Cameron sculp.
An. Fyfe del.

Tab. II.

Thos. Donaldson delt. et Sculpt.

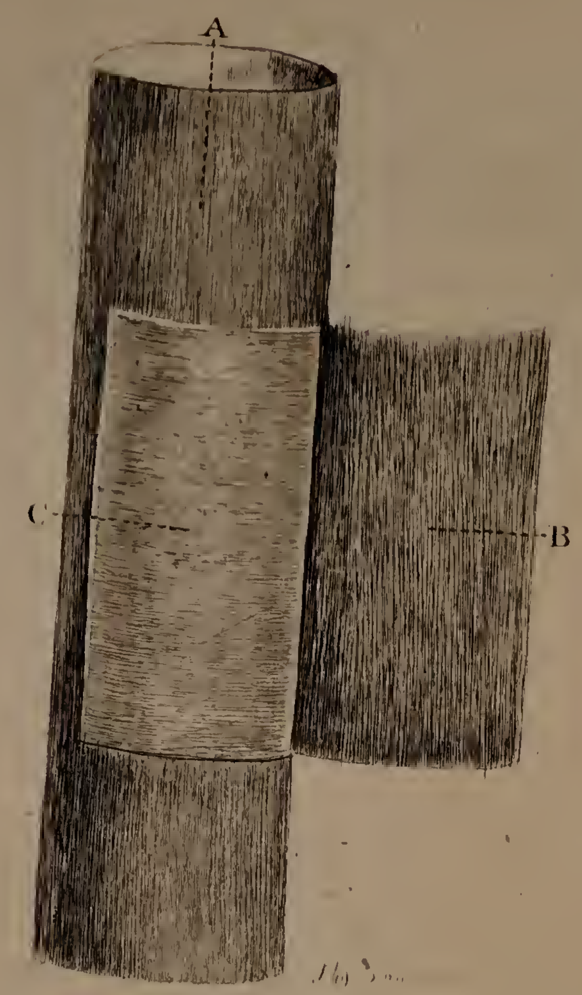


Thos. Donaldson delt. et Sculpt.

TAB. III.

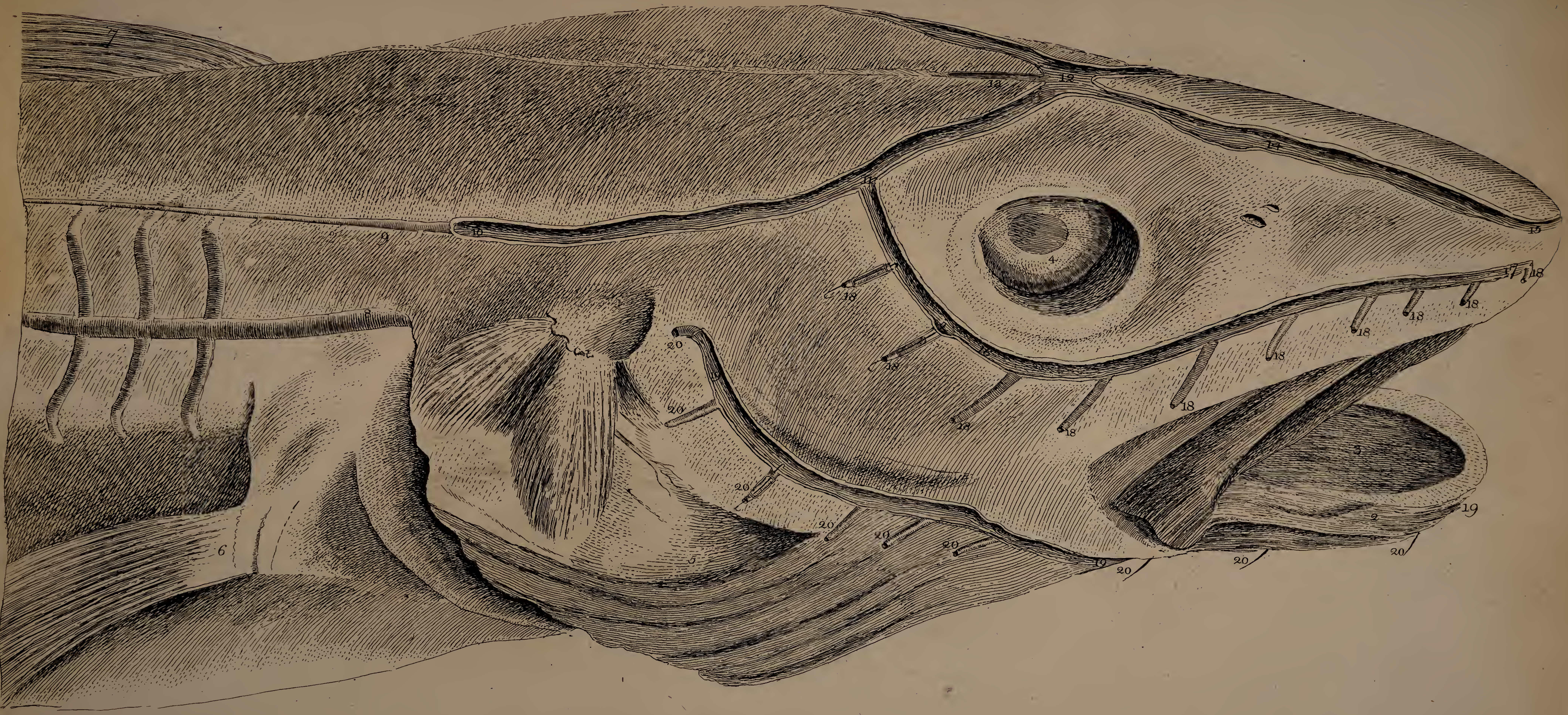
A. Fyfe delt. *G. Cameron sculpt.*

Tab. III.



Tab. IV.

TAB. V.



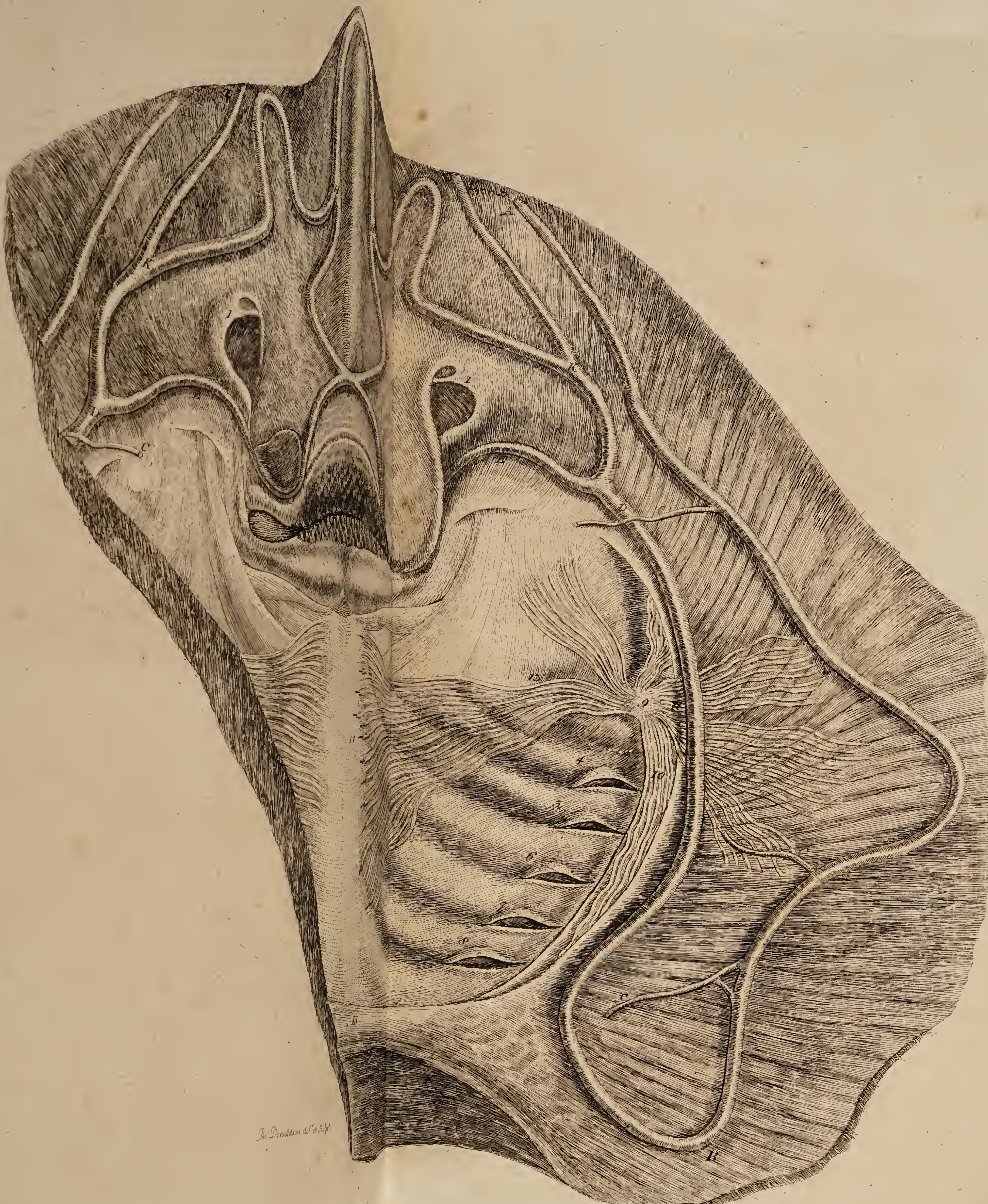
A. Fyfe del.t

G. Cameron sculp.

TAB. VI

Thos. Donaldson delt. et Sculpt.

TAB. VI

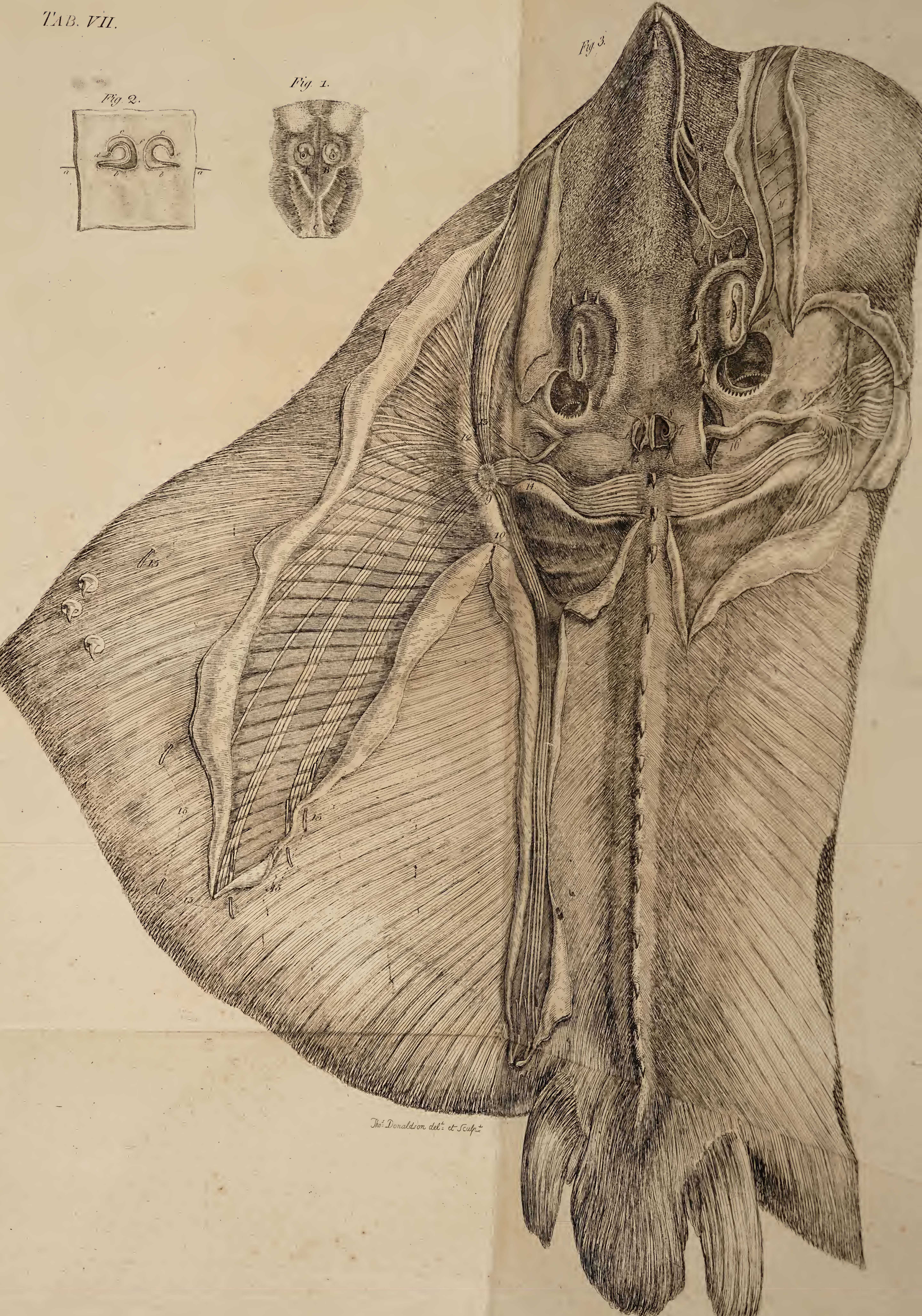


TAB. VII.

Fig 2.

Fig 1.

Fig 3.



Thos. Donaldson delt. et Sculpt.

Fig. 2.

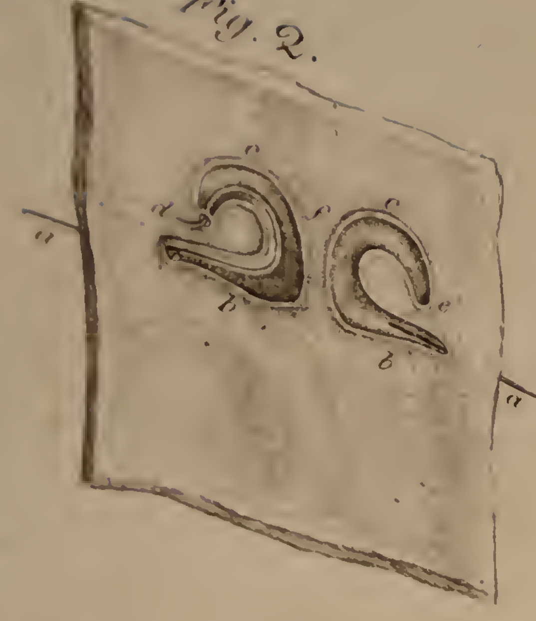


Fig. 1.

Fig 3.

Thos. Donaldson delt. et Sculpt.

TAB. VIII.

Fig. 1.

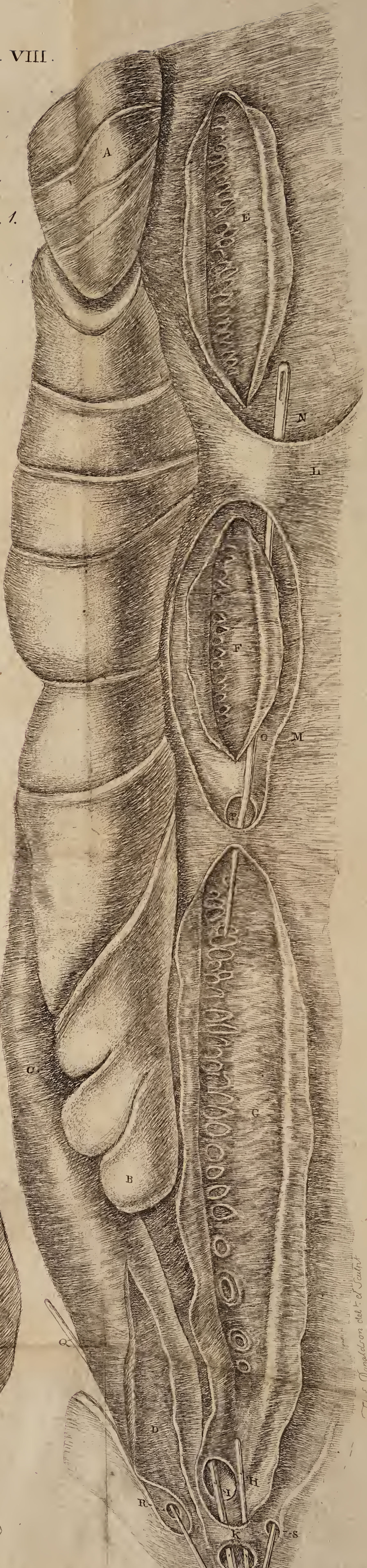
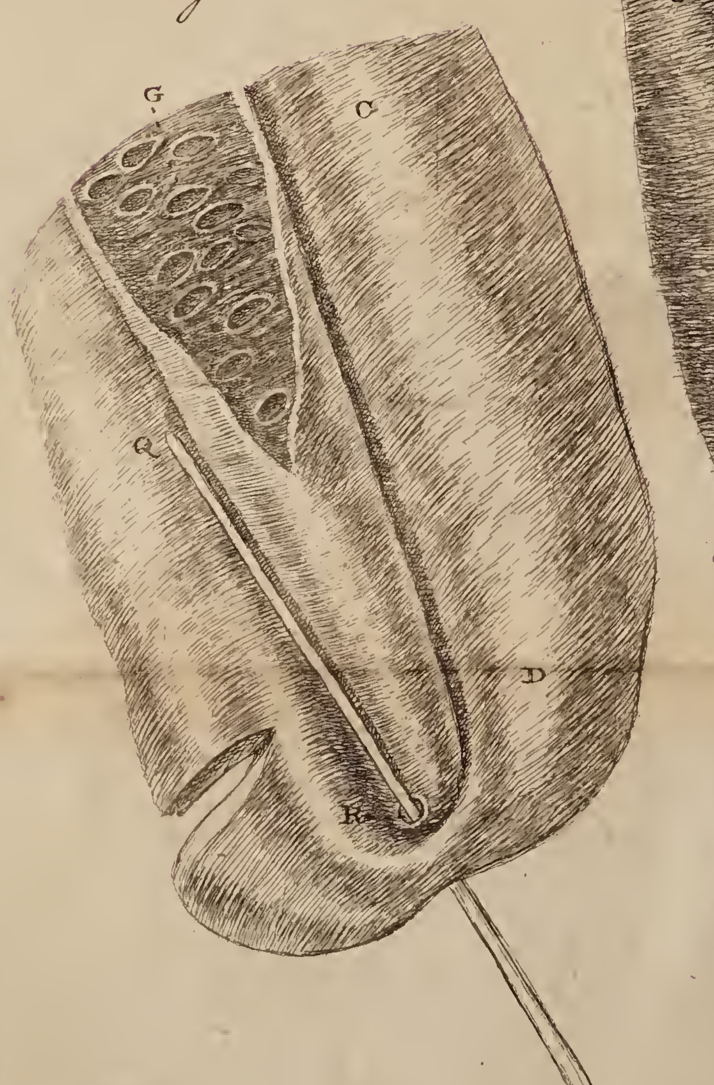


Fig. 2.



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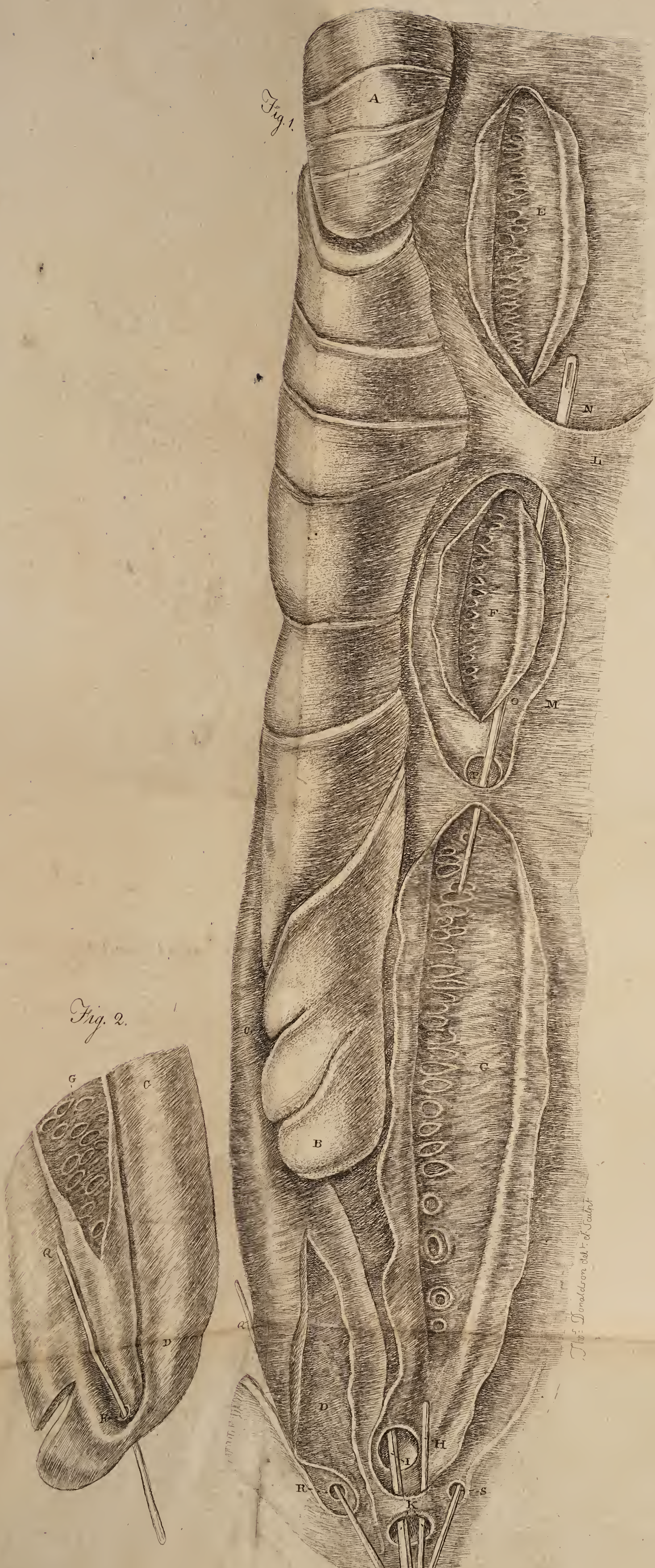


Fig. 1.
A
E
N
L
F
O
M
G
C
B
D
H
I
K
R
S
Fig. 2.
G
C
Q
D
Thos: Donaldson delt. et Sculpt

TAB. IX

Fig. 1.

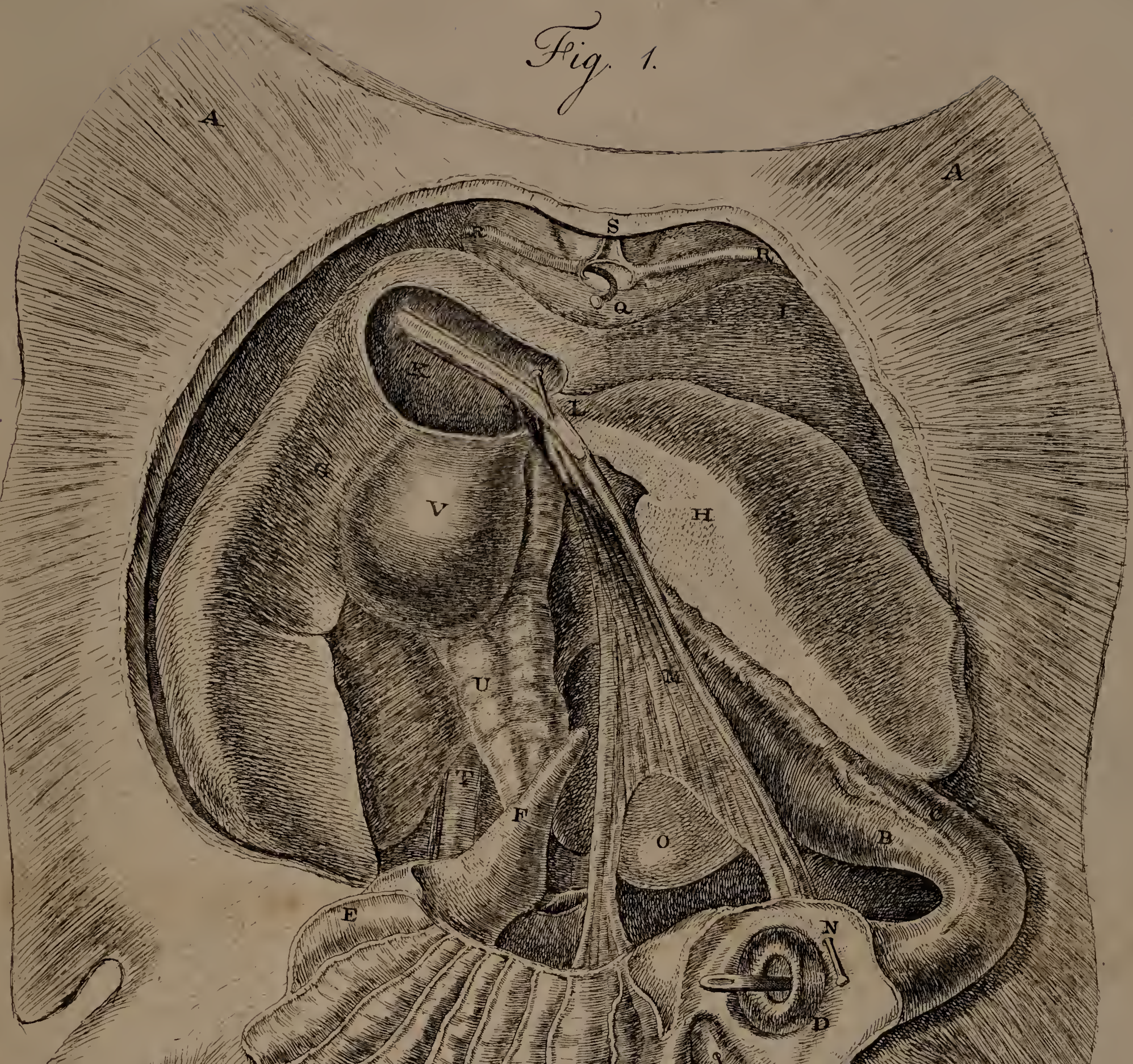
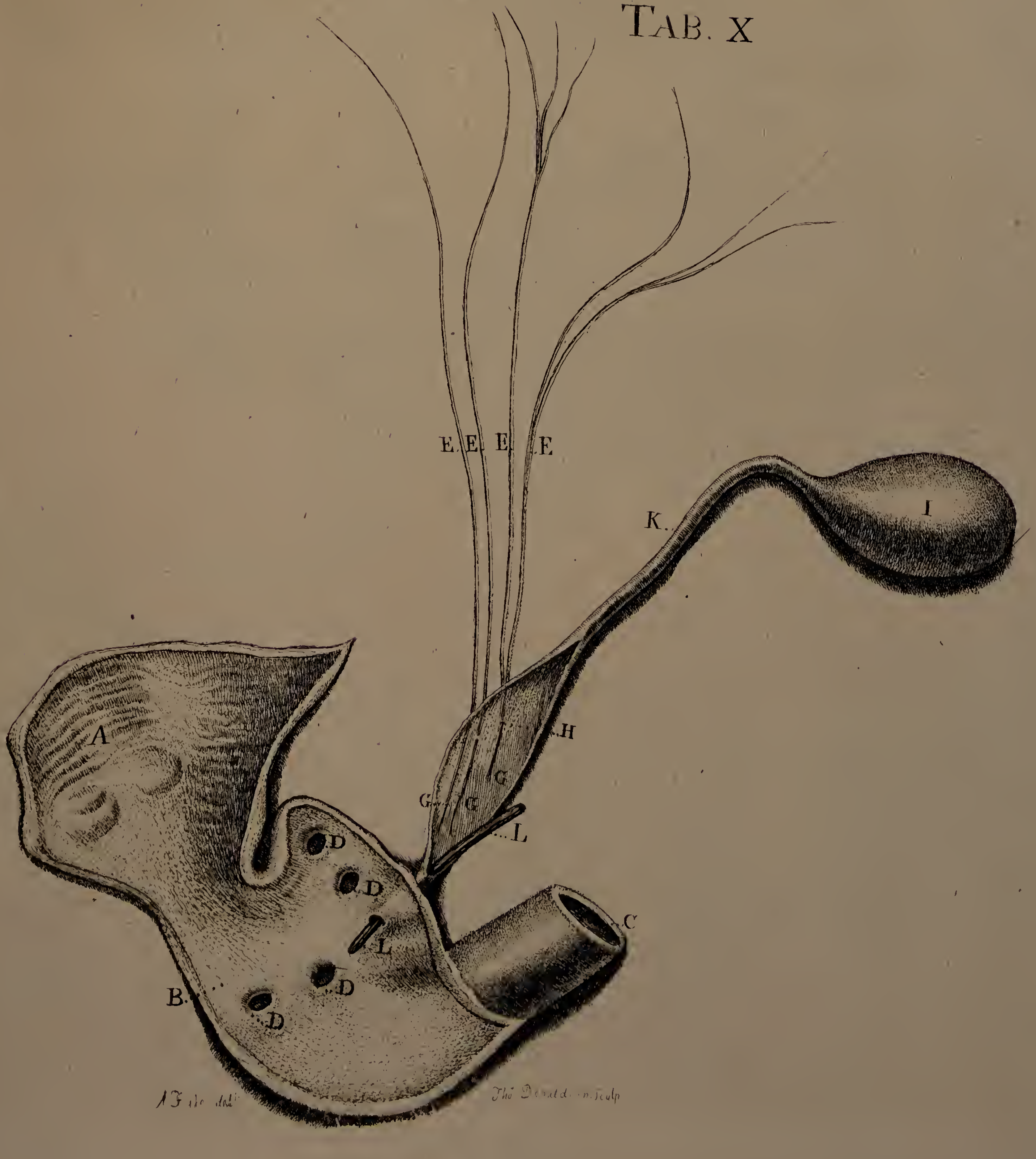


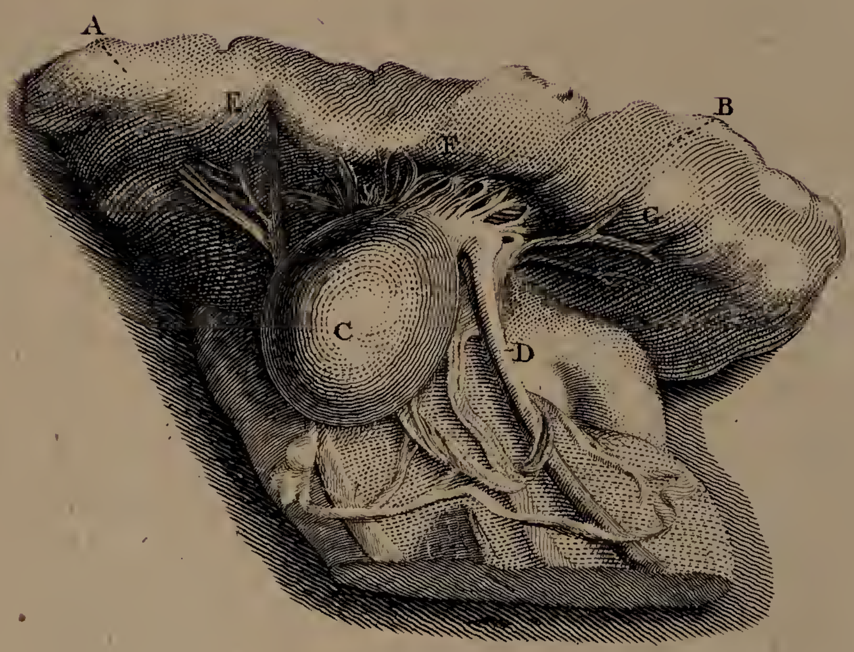
Fig. 2.

TAB. IX. X

TAB. X

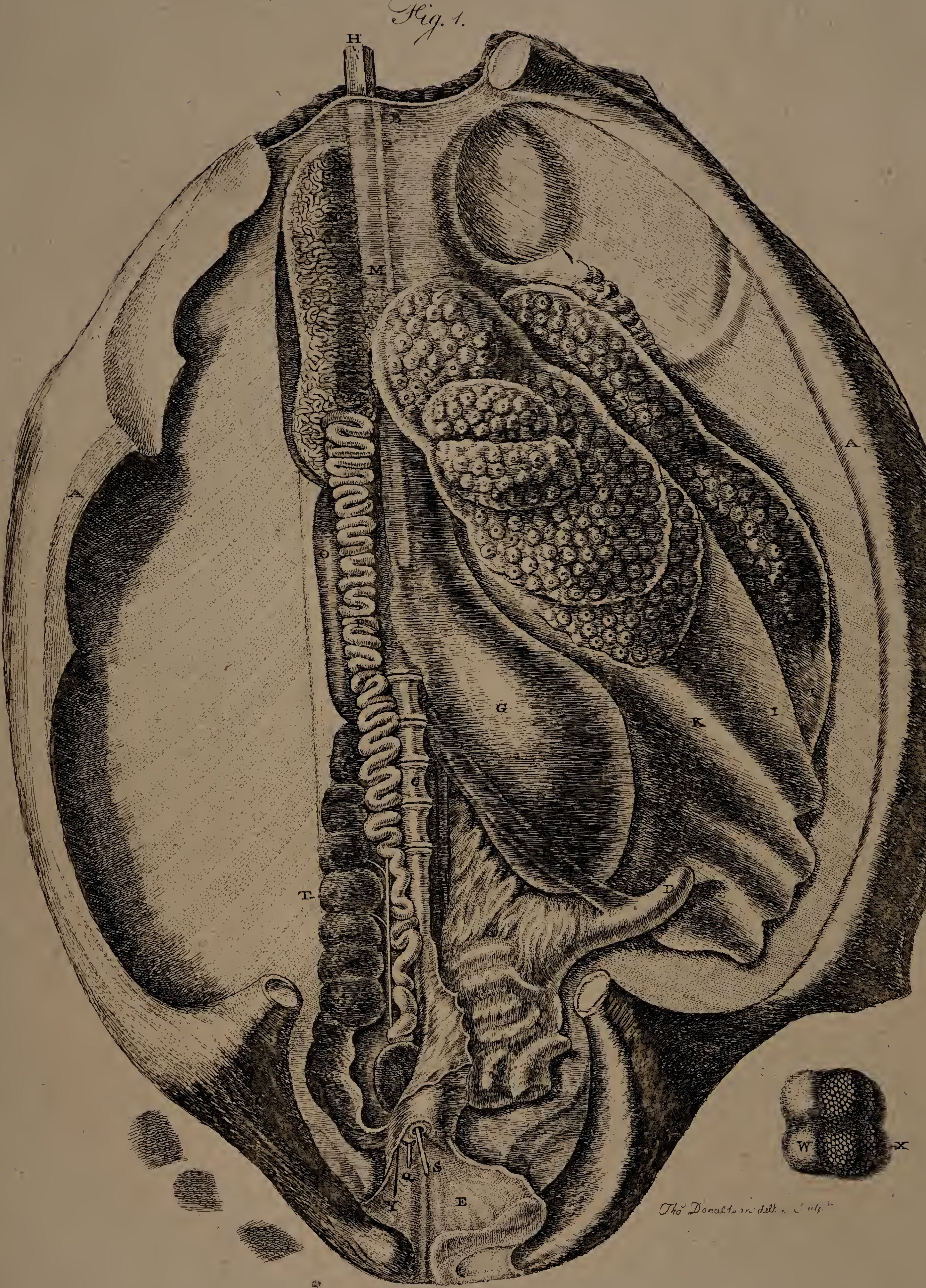


TAB. X. ✻

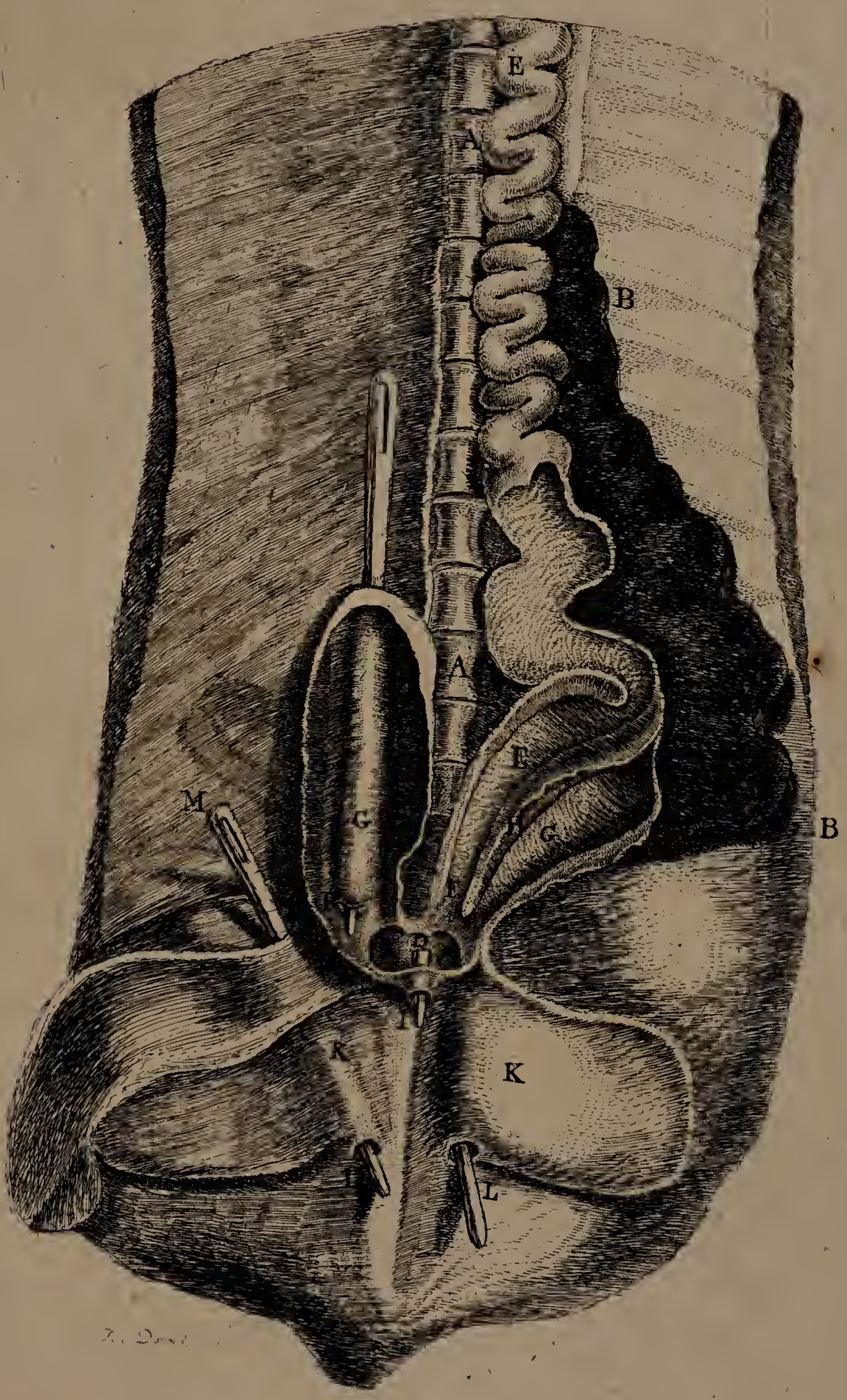


I Beugo del et sc

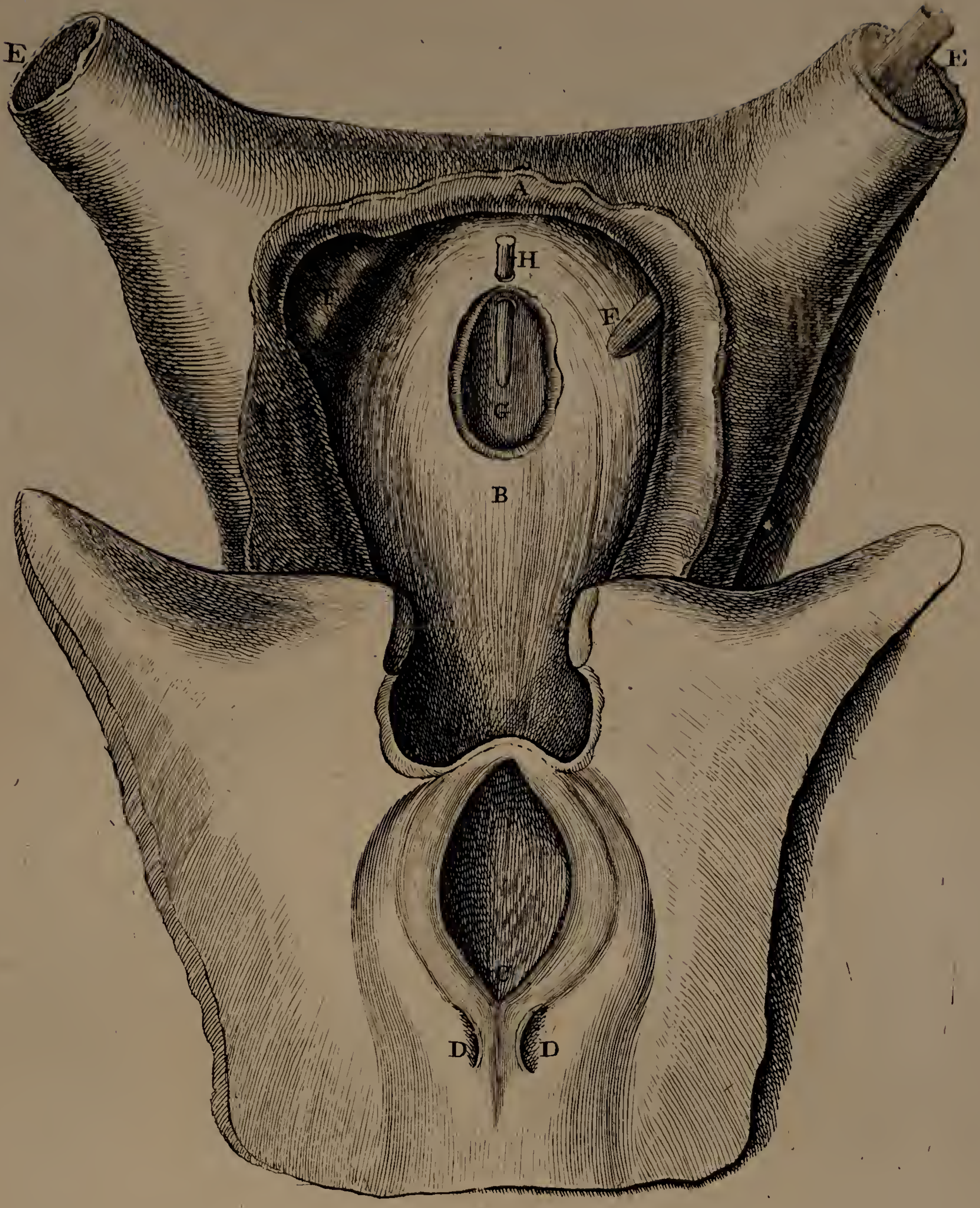
TAB. XI



TAB. XII



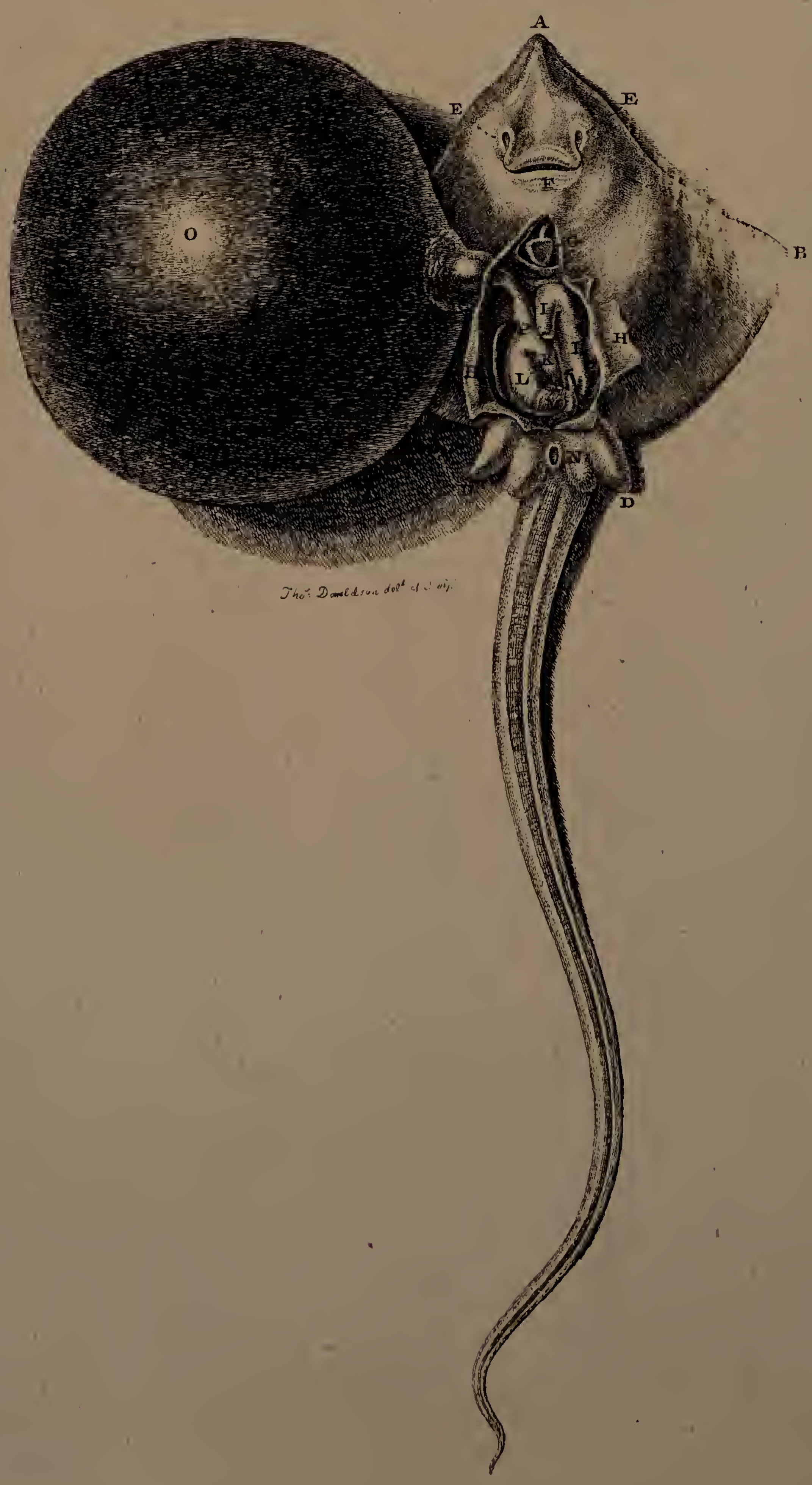
TAB. XIII



A. Fyfe delt.

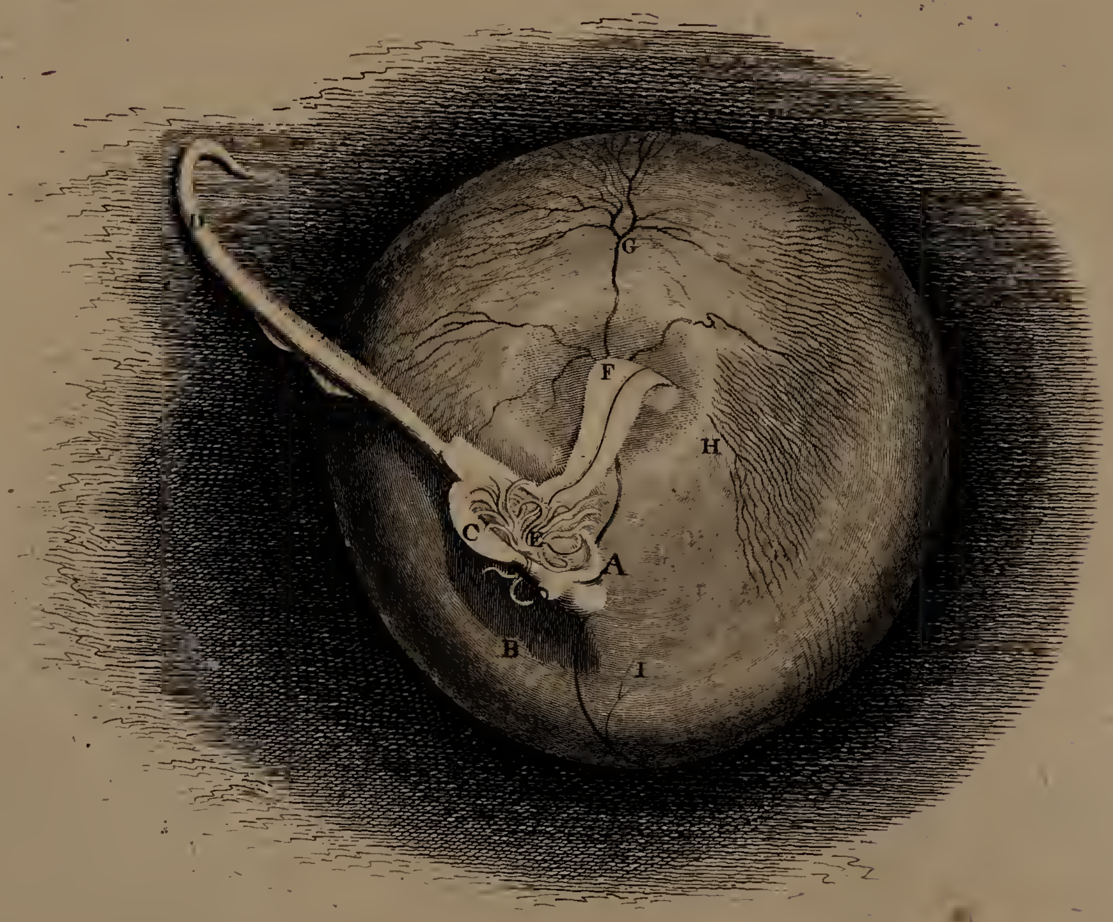
G. Cameron sculpt.

TAB. XIV



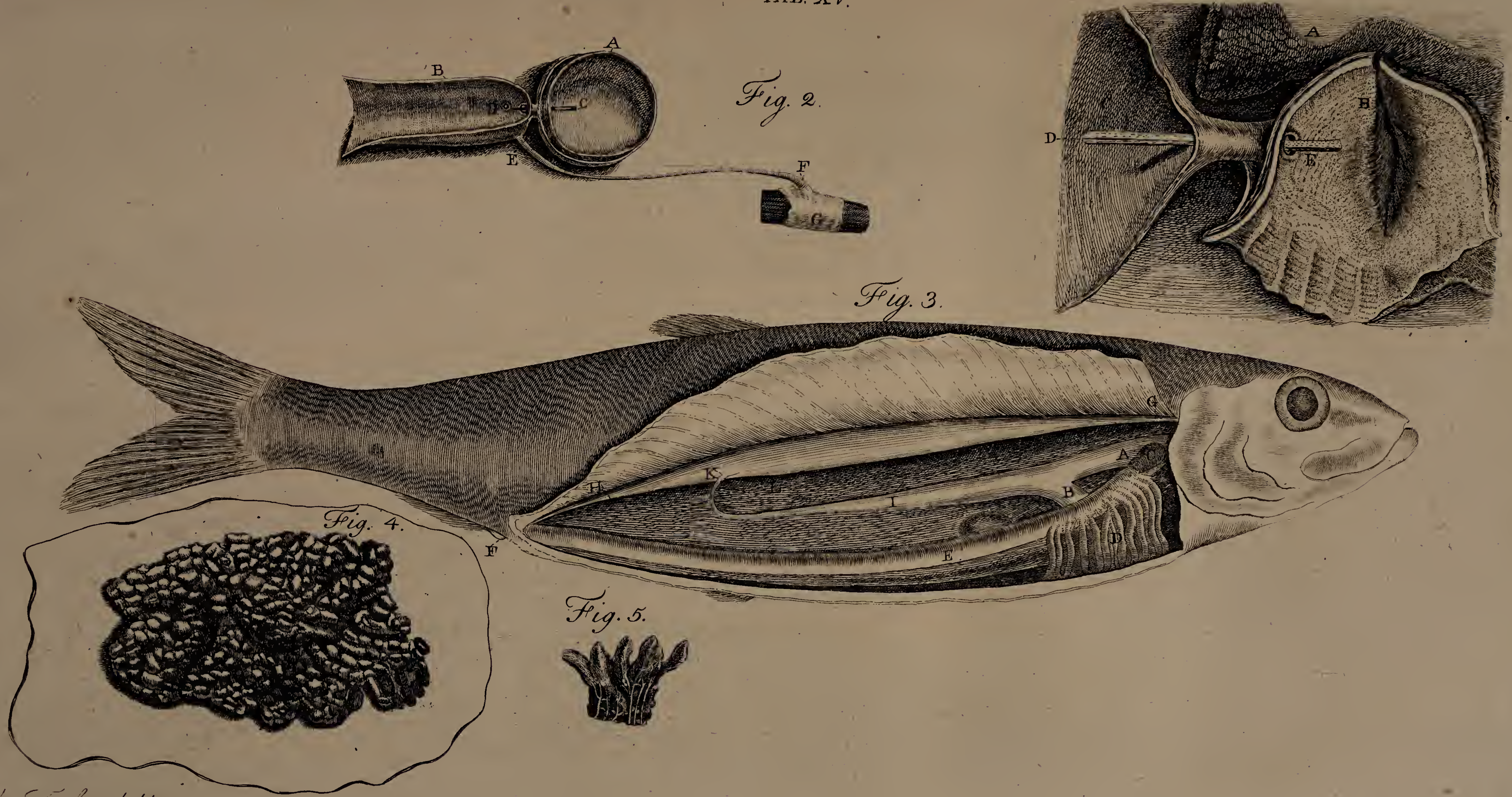
Thos. Donaldson delt. et sculp.

TAB. XIV. ✱



I Beugo del et fc

TAB. XV.



J. Fyfe delt.

G. Cameron sculp.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Thos. Donaldson del. et Sculp.

TAB. XVI

Fig. 1.

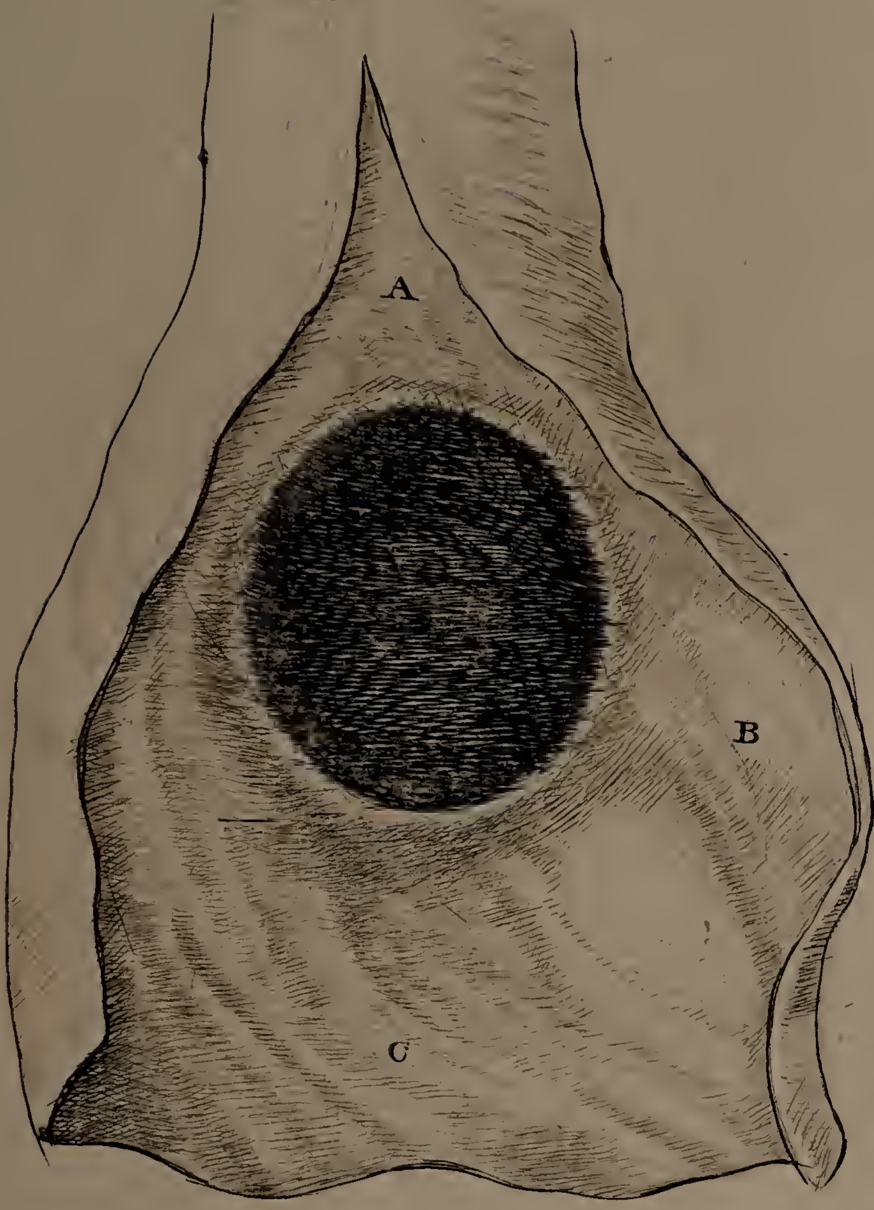
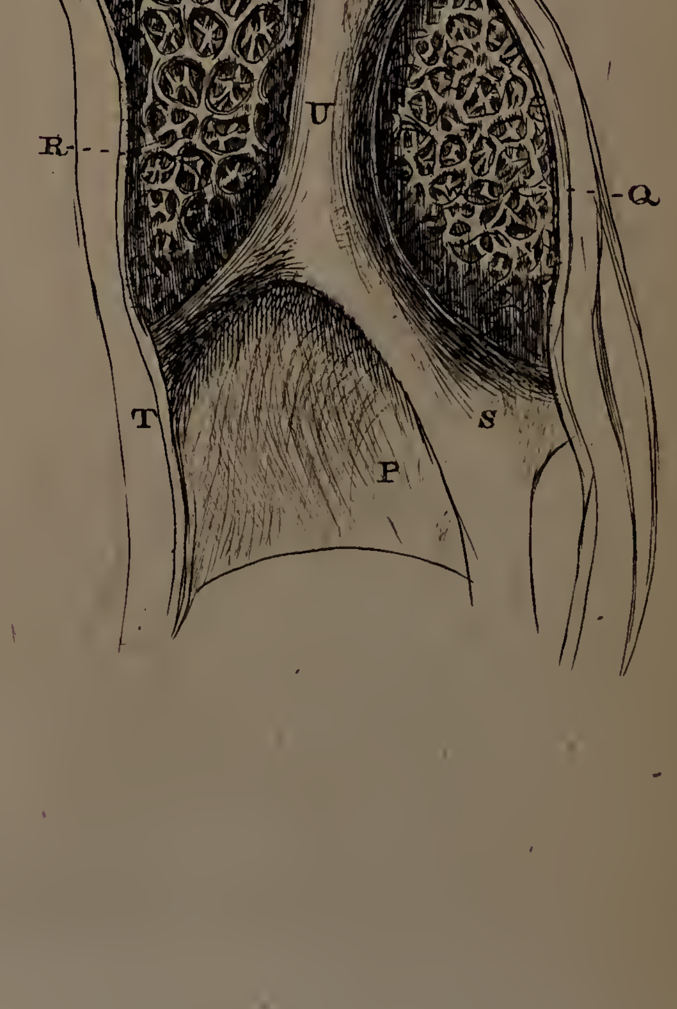


Fig. 2.

Fig. 3.

Fig. 4.



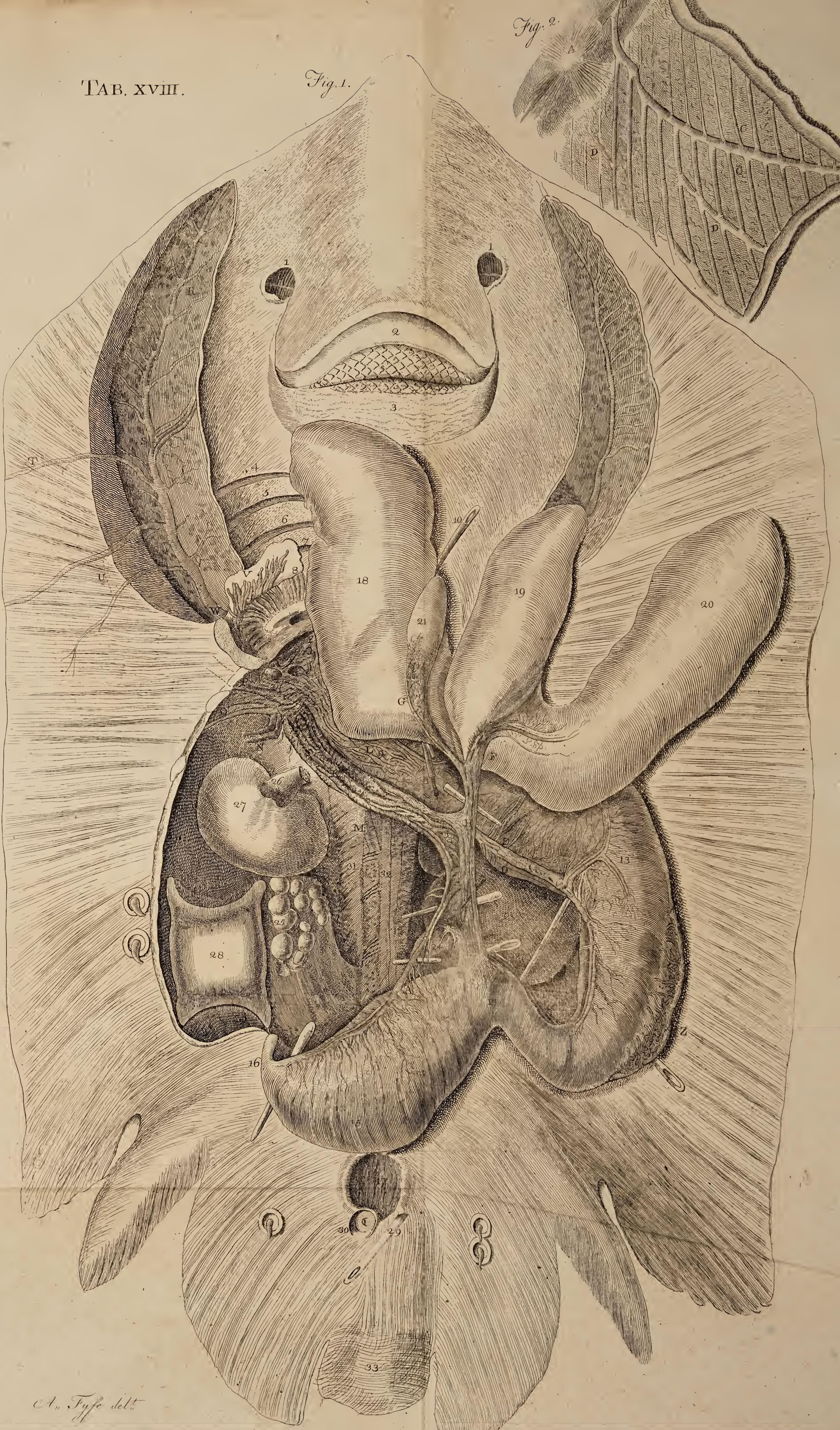
TAB. XVII

Fig. 1.

Fig. 2.

T. Donaldson del.t *G. Cameron sc.*

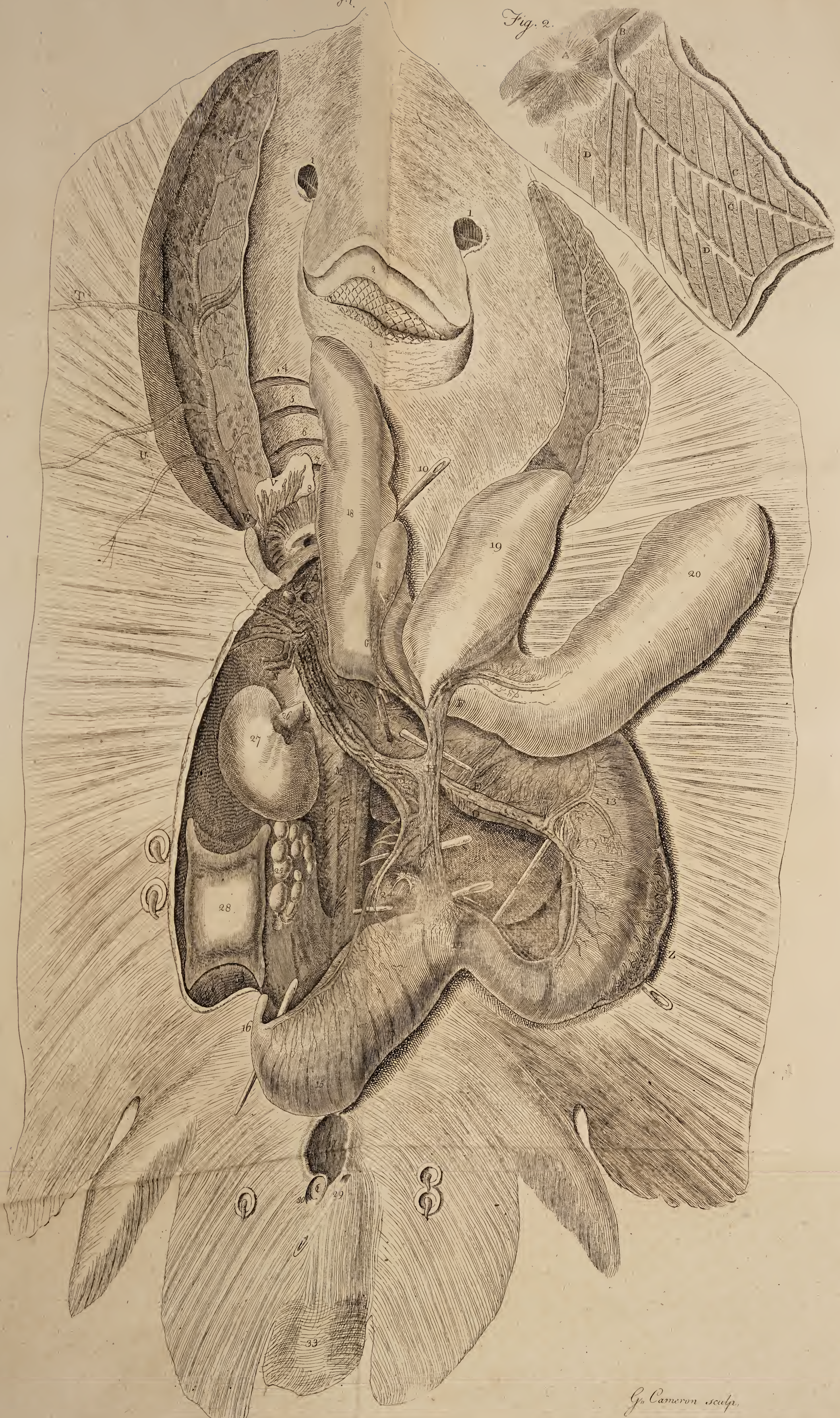
TAB. XVIII.



A. Fyfe delt.

Gn. Cameron sculp.

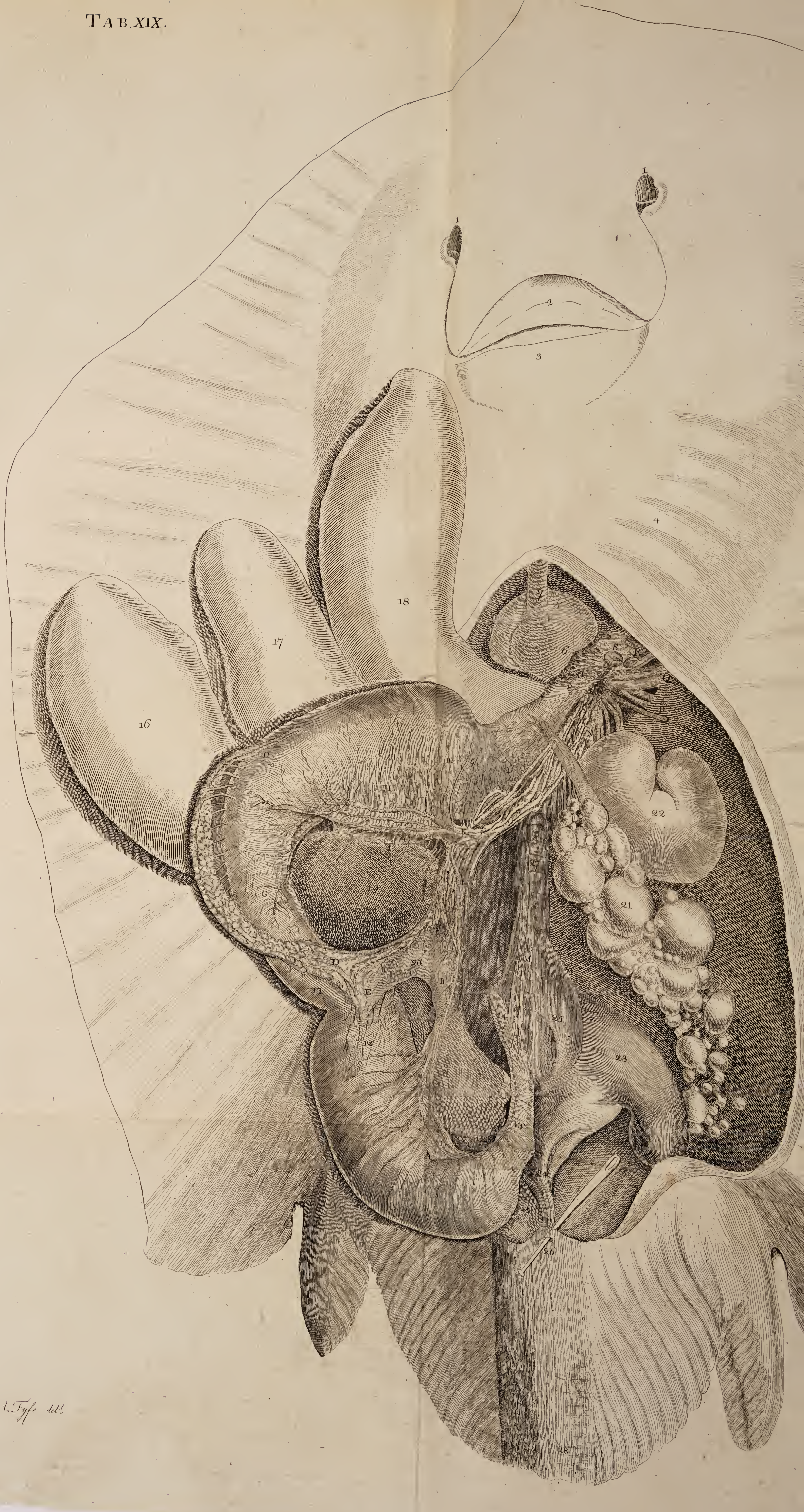
Fig. 1. Fig. 2.



Al. Fyfe delt.

Gn Cameron sculp.

TAB. XIX.



A. Fyfe del.

G. Cameron sculp.

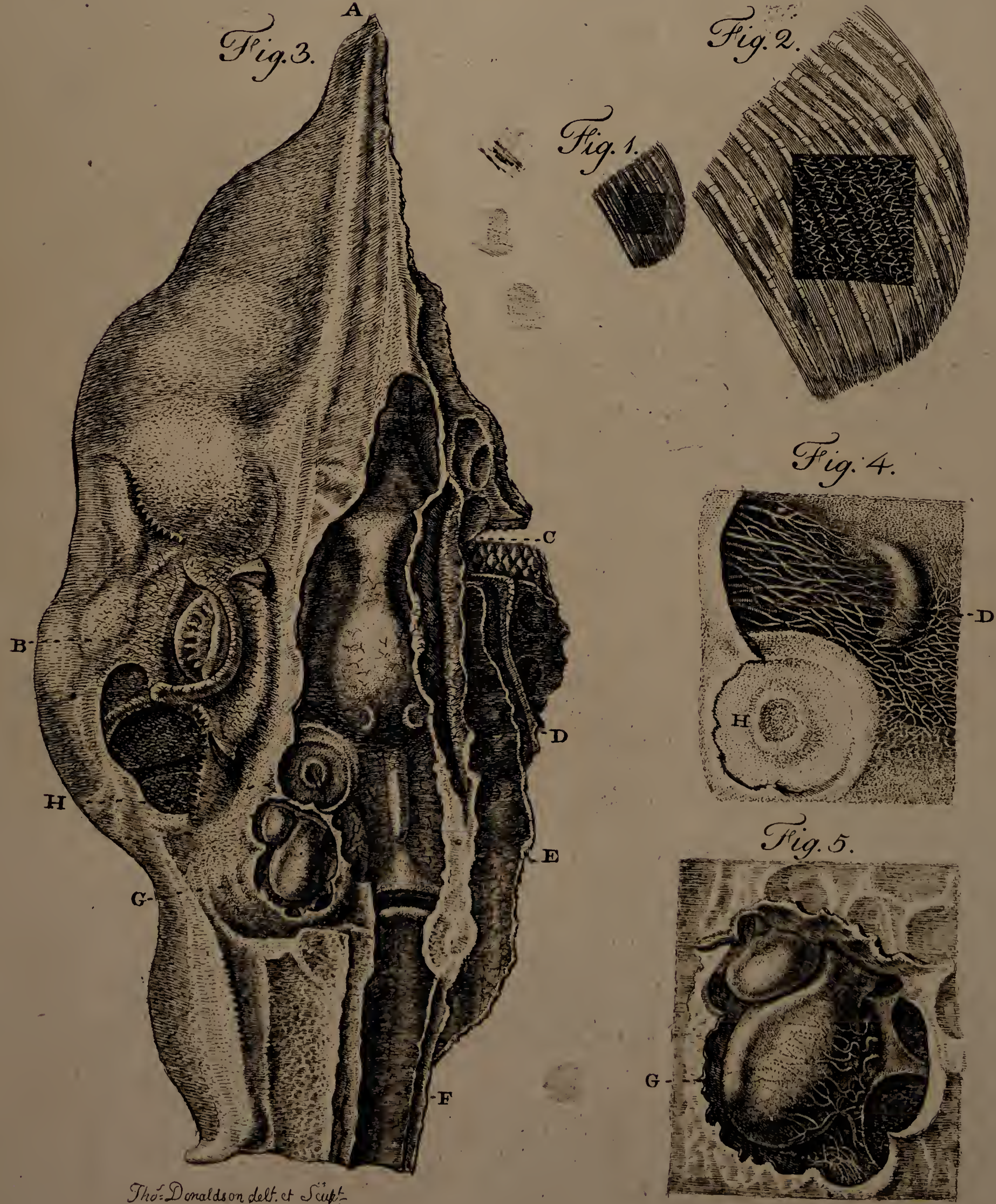
G. Cameron sculp.

TAB. XX

T. Donaldson delt.

G. Camero sculp.

TAB. XXI.



Thos. Donaldson delt. et Sculpt.

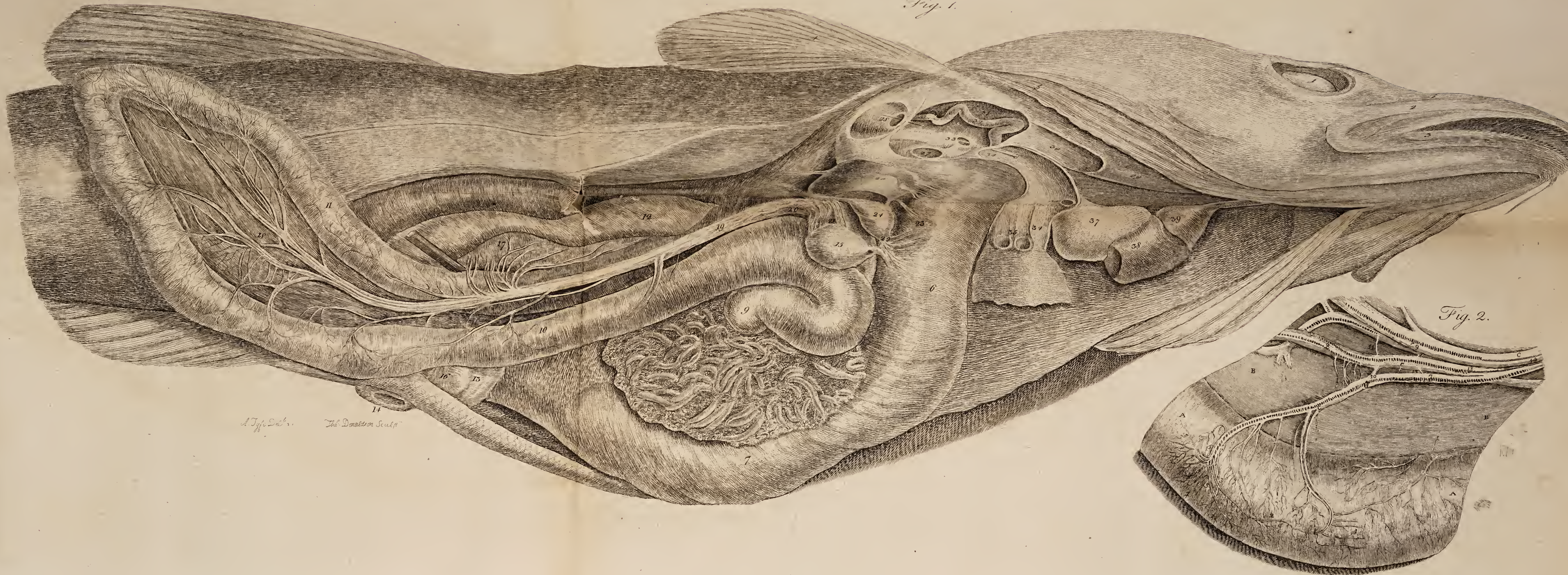
TAB. XXII.

Fig. 1.

Fig. 2.

TAB. XXII.

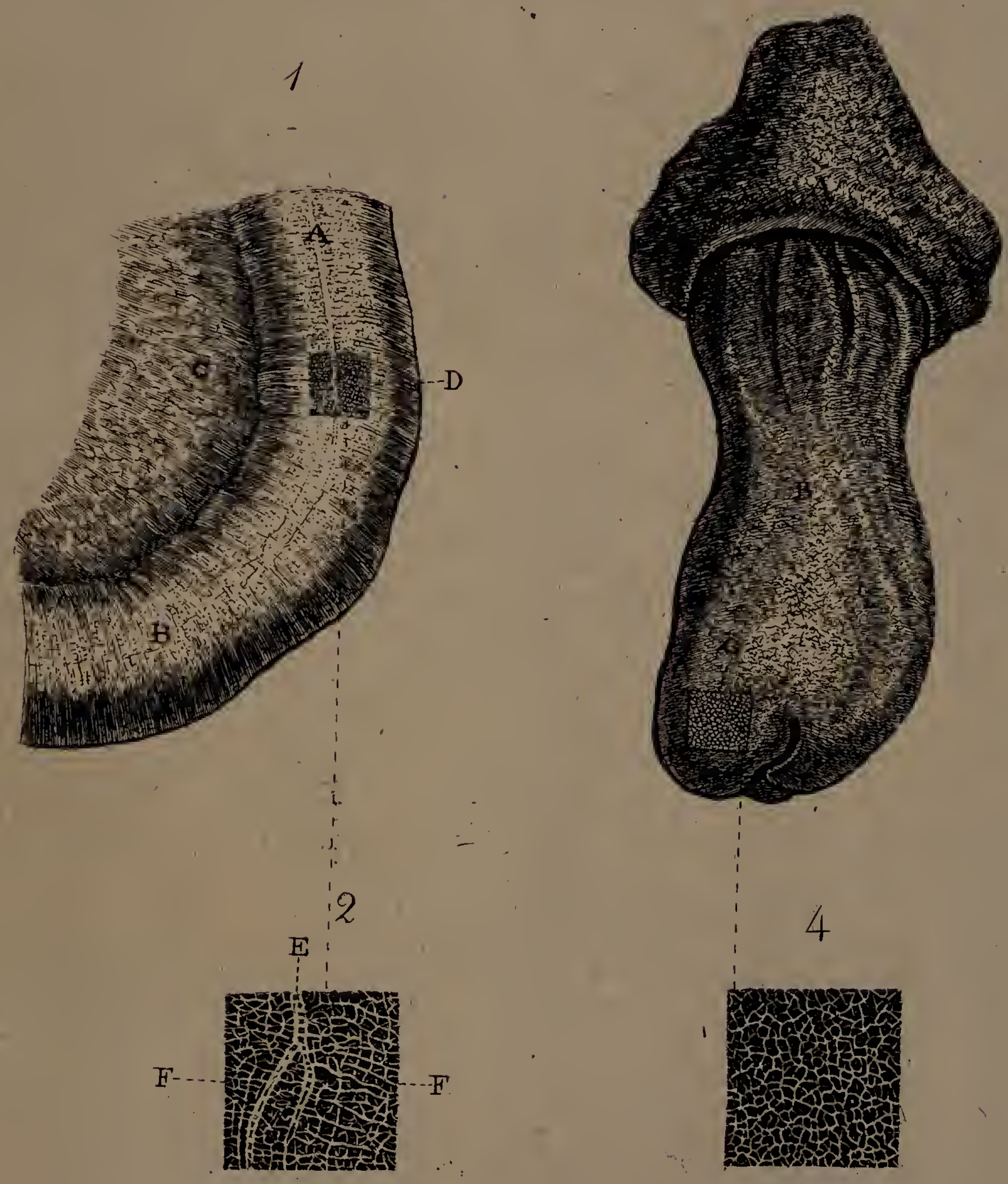
Fig. 1.



A. Tyfs Del. Thos. Donaldson Sculpt.

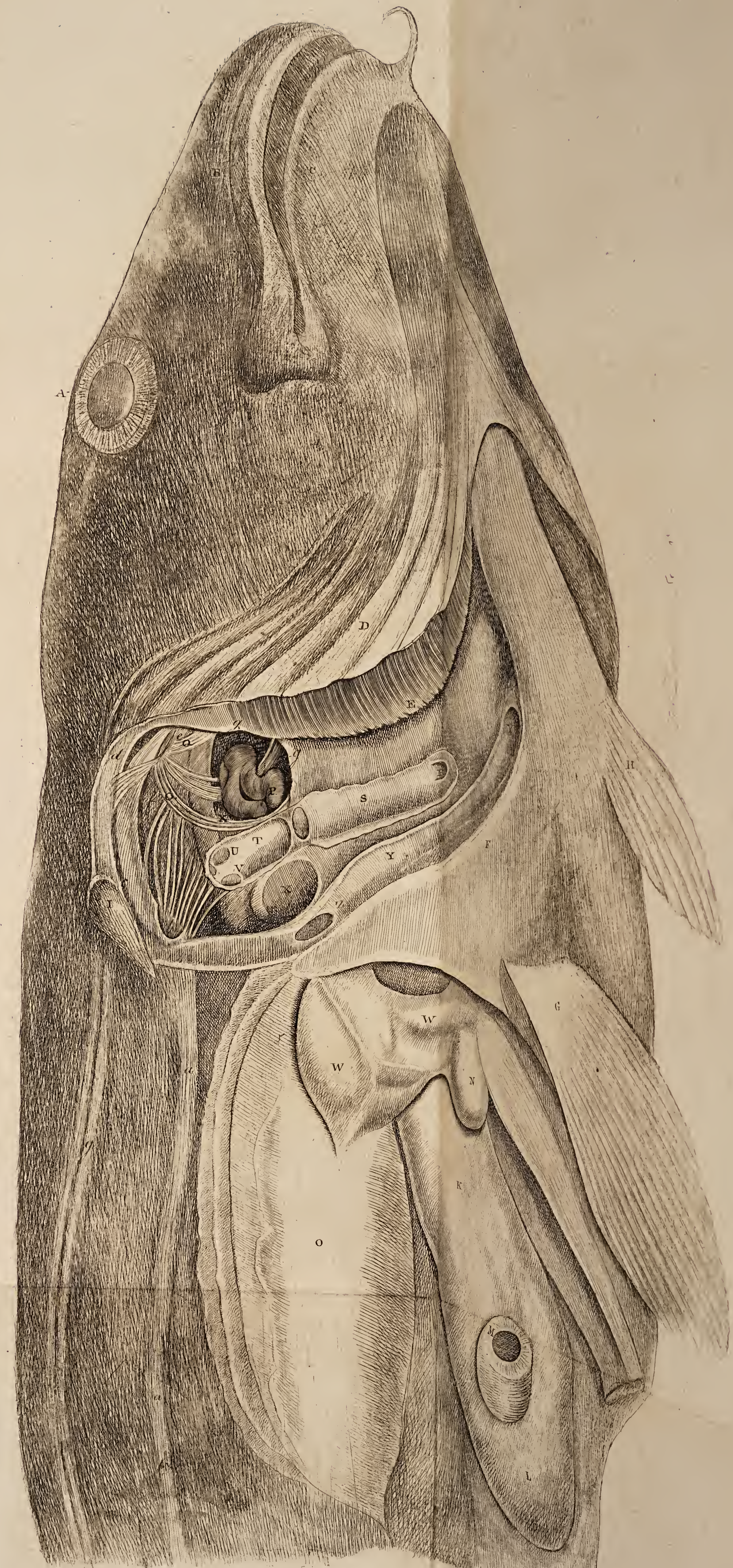
Fig. 2.

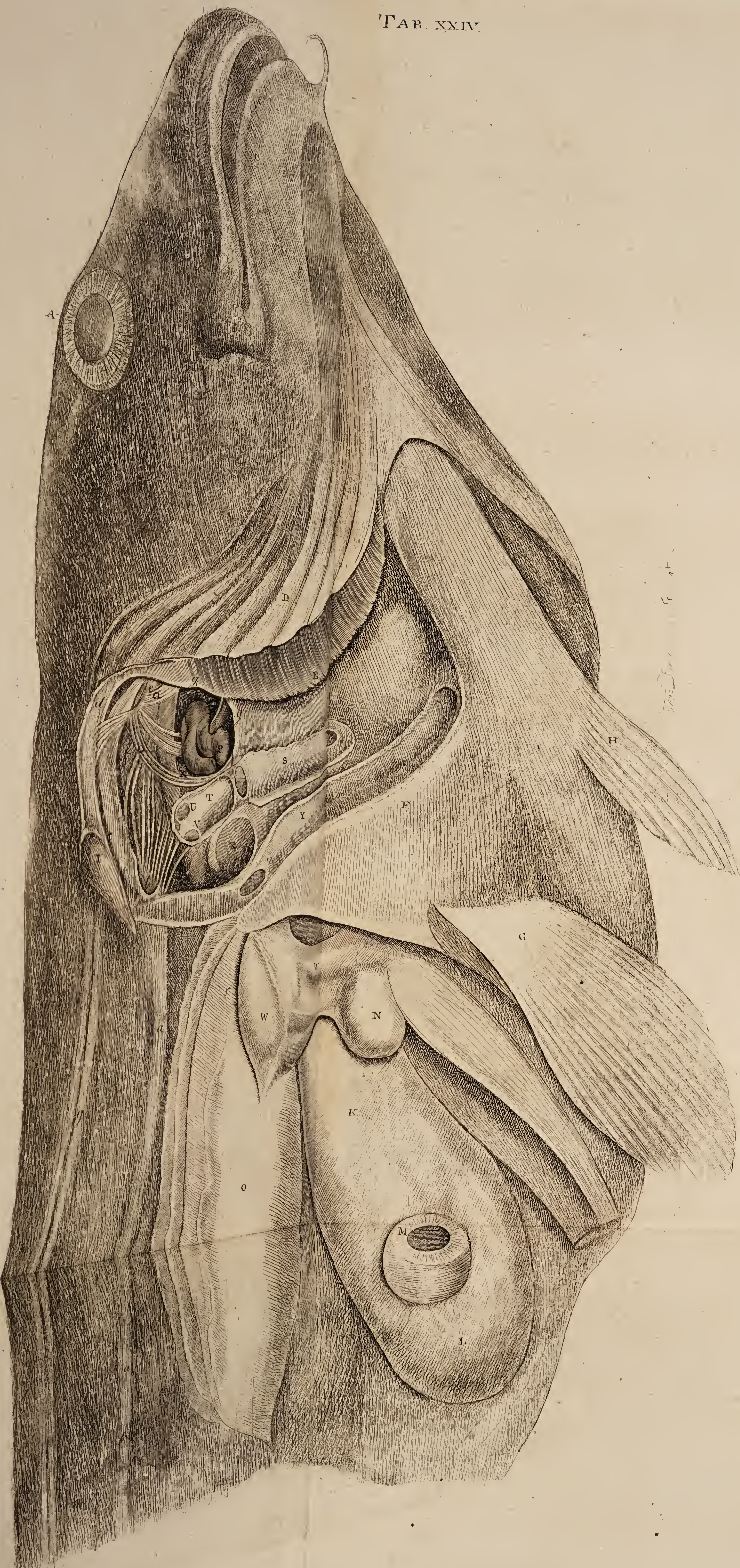
TAB XXIII



Thos. Donaldson del. et sculpt.

TAB. XXIV.

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TAB. XXV.

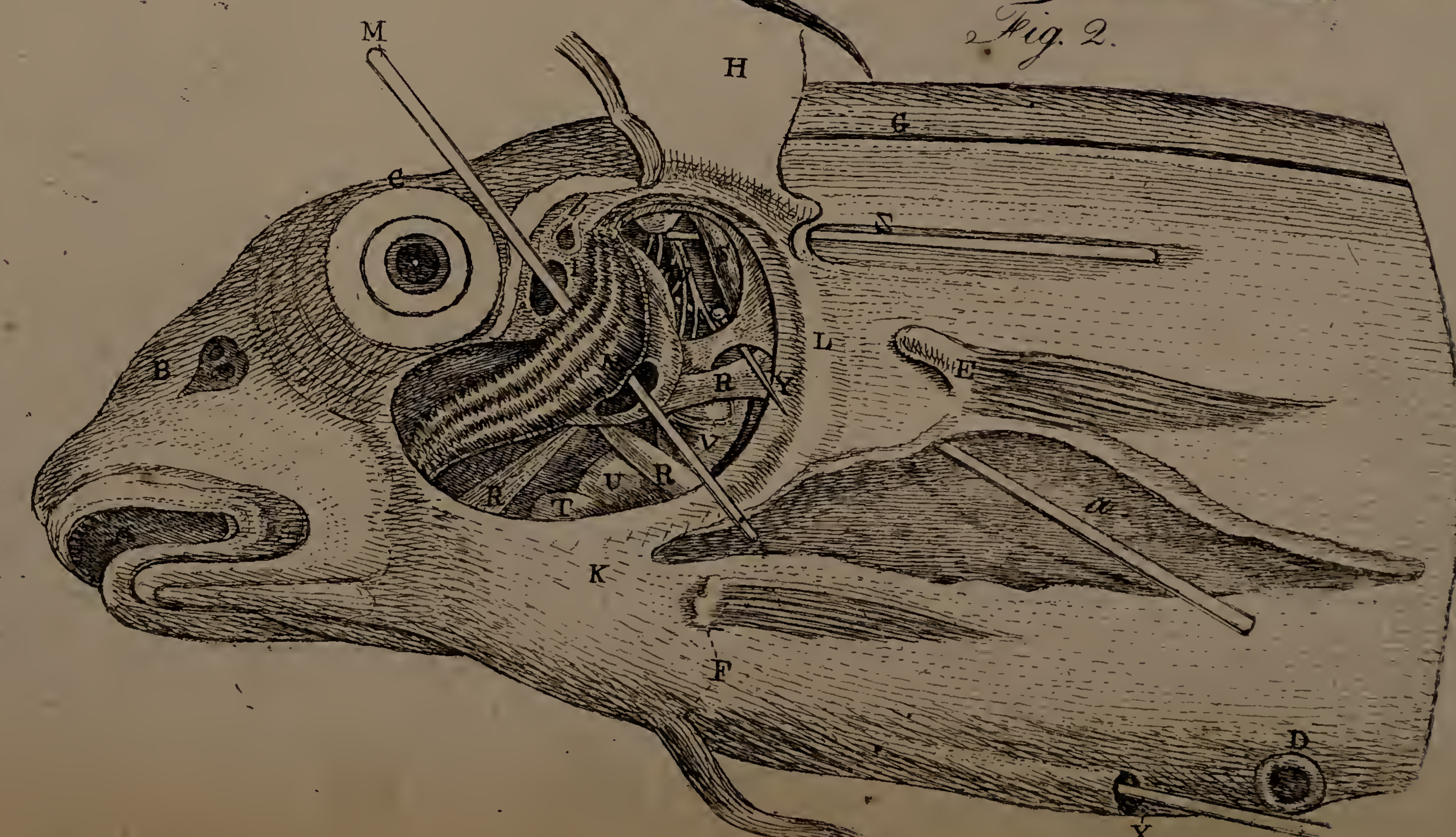
Fig. 1.

Fig. 2.

Fig. 1.

Thos. Donaldson delt. et Sculpt

Fig. 2.



TAB. XXVI.

Fig. 1.

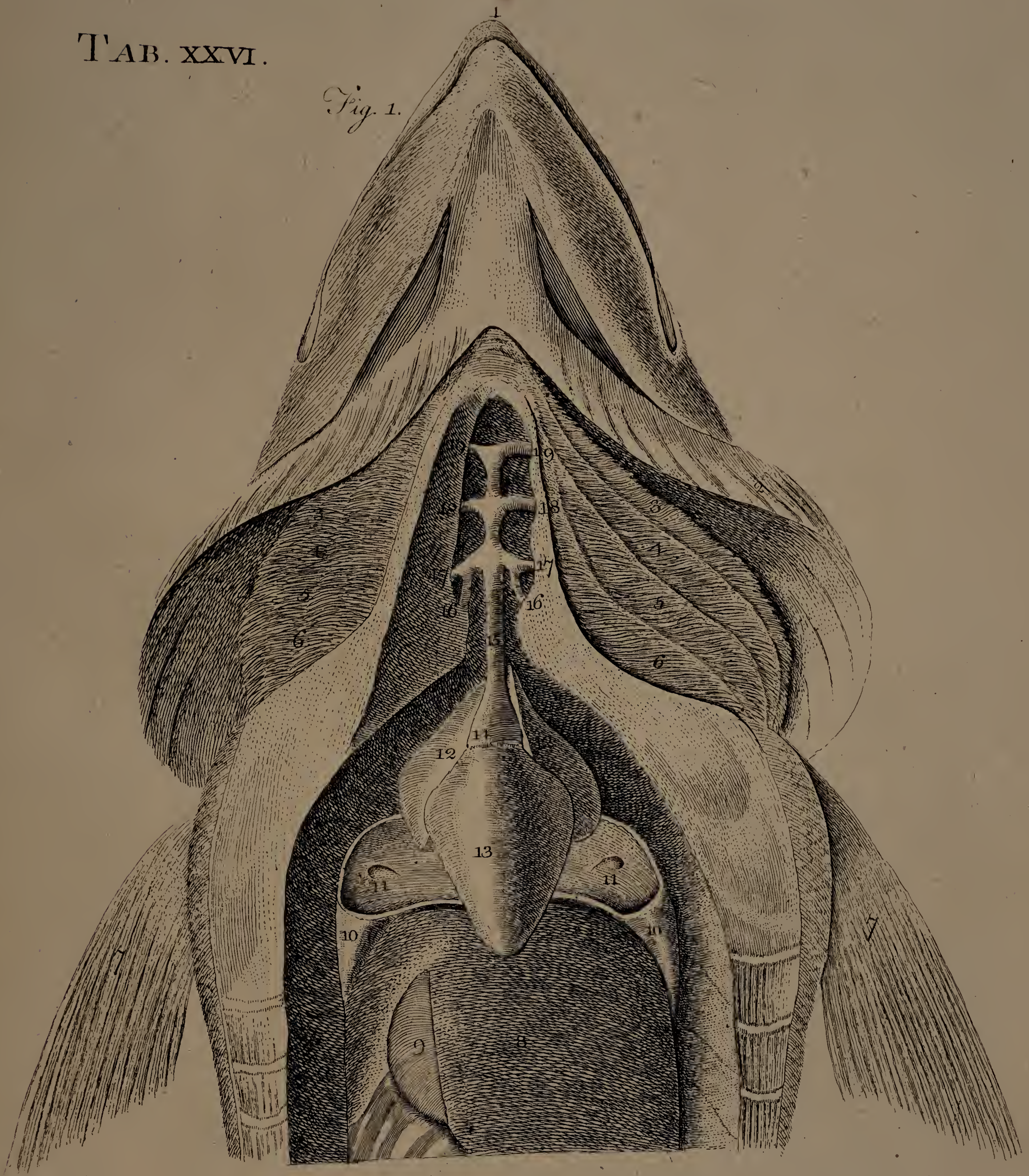
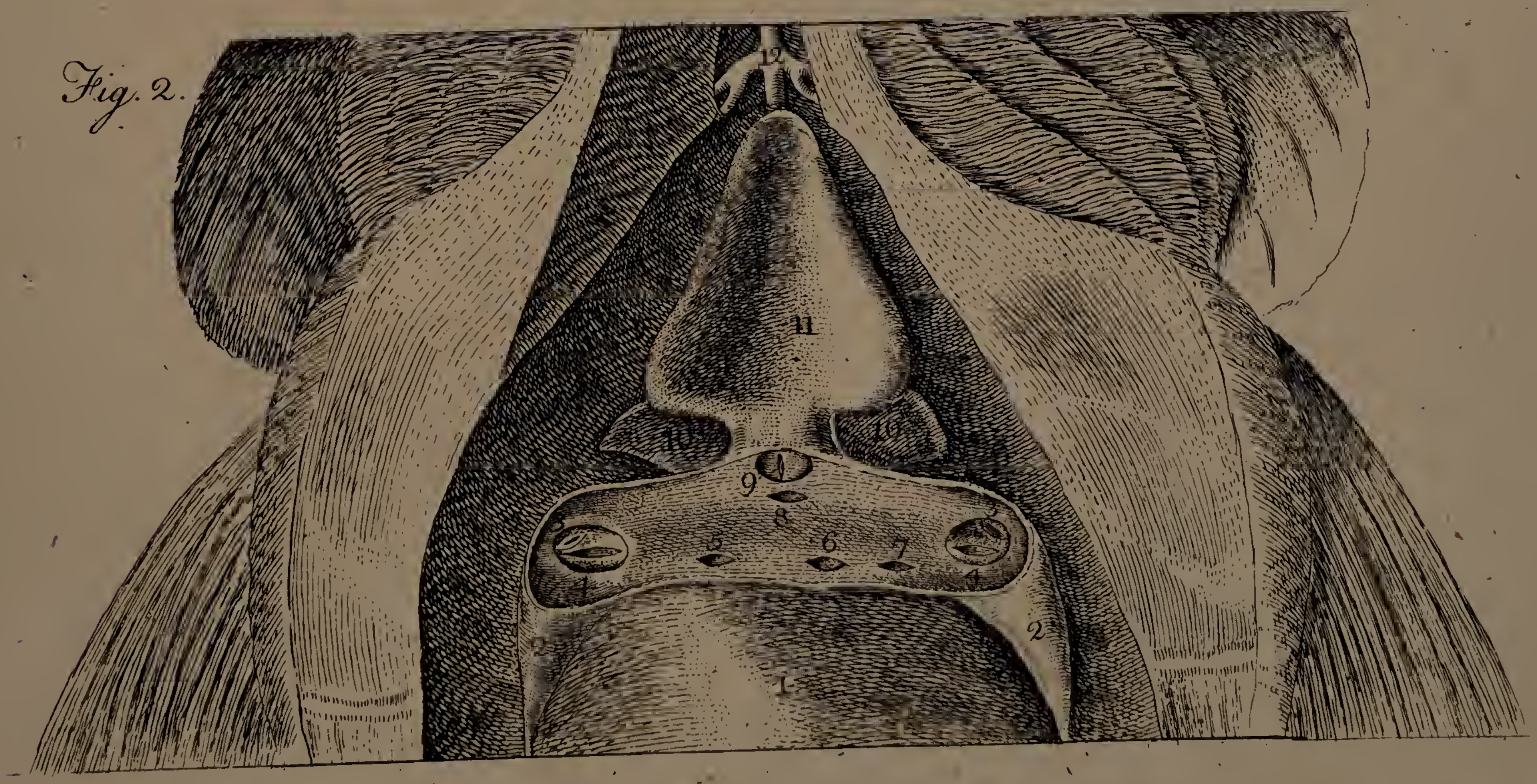


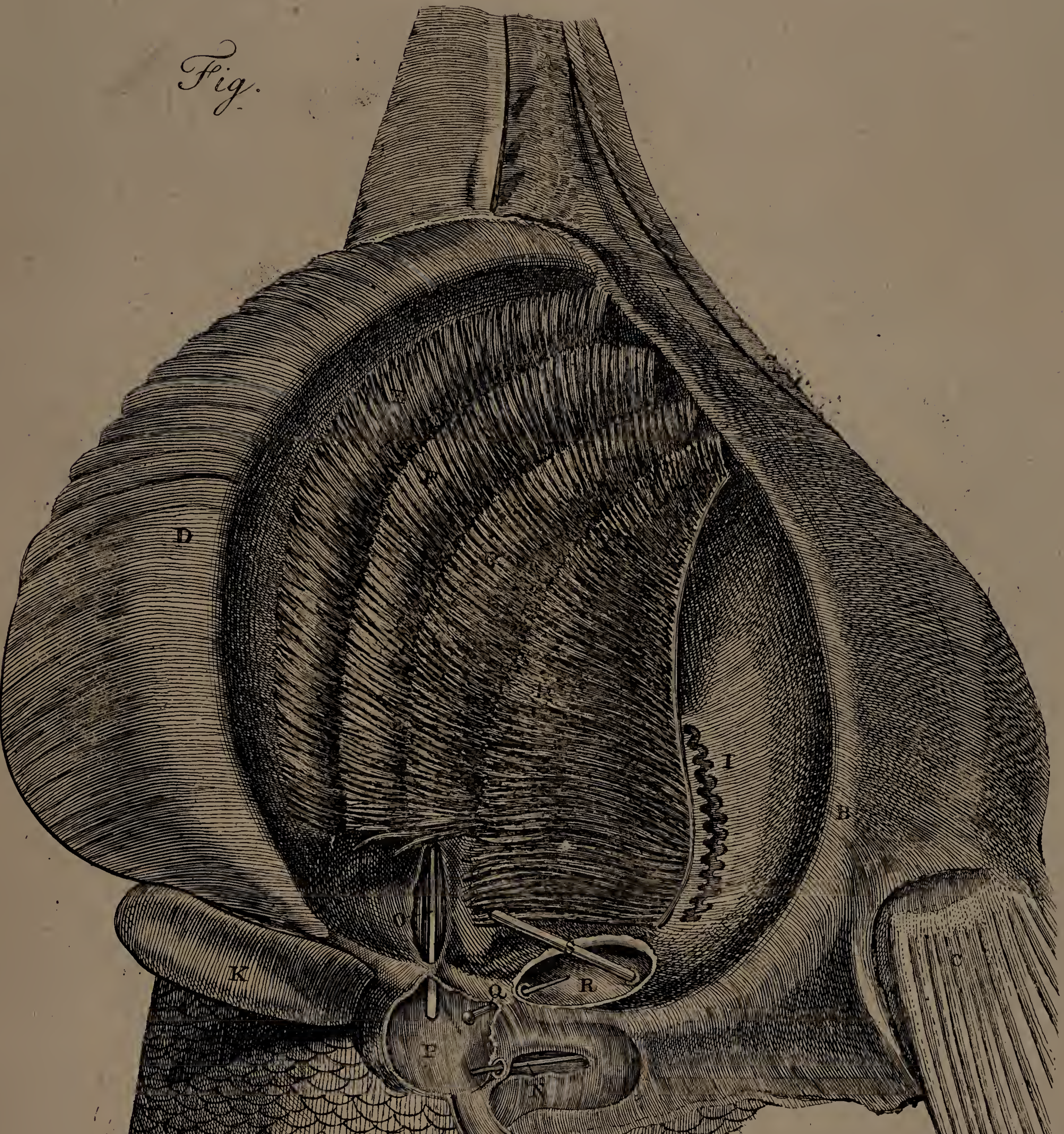
Fig. 2.



A. Fyfe delt. G. Cameron sculp.

TAB. XXVII

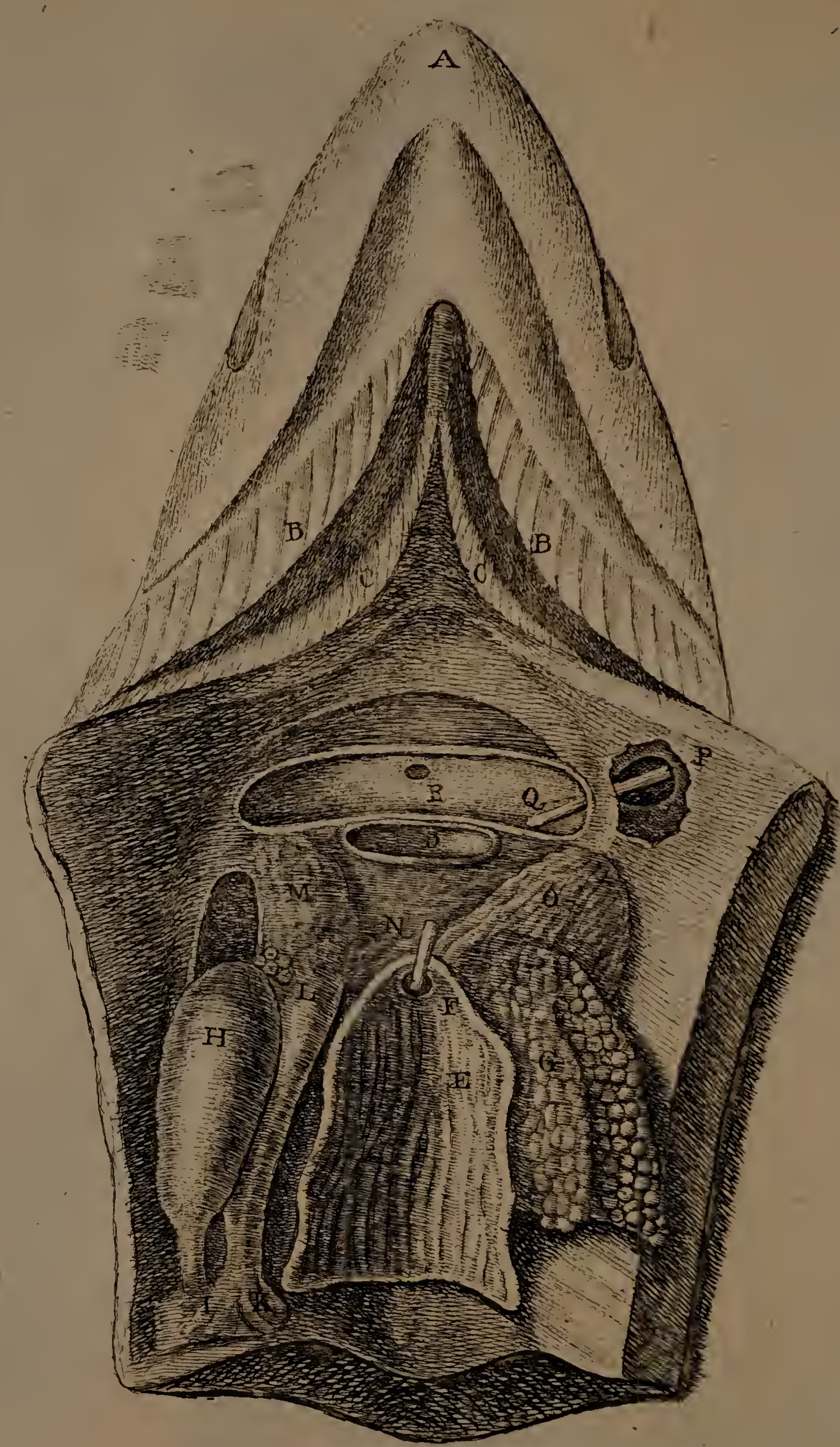
Fig.



TAB. XXVIII.

Thos. Donaldson del. Sculpt.

TAB. XXIX



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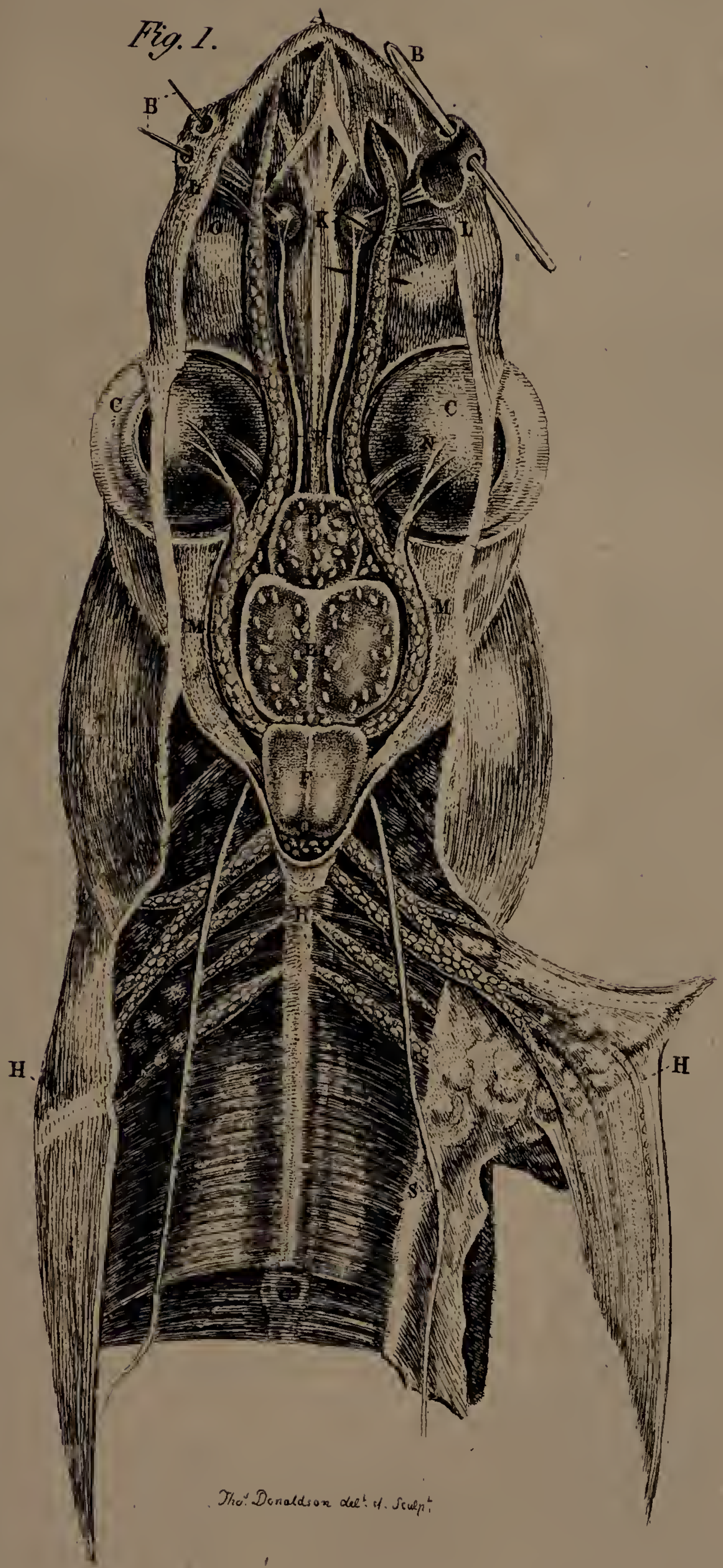
Thō. Donaldson Sculpt

TAB. XXXI.

Fig. 1.



Thos. Donaldson delt. et Sculpt.

Fig. 2.

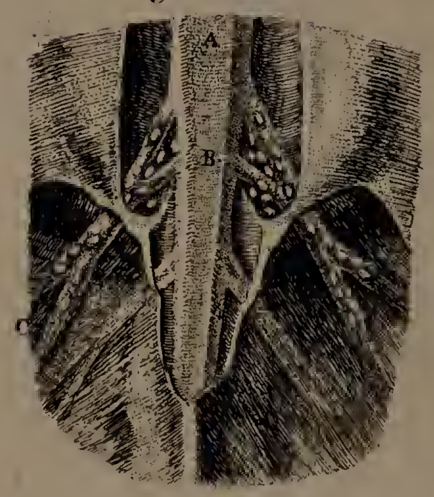


Fig. 3.

TAB. XXXII

TAB. XXXIII.

Fig. 1.

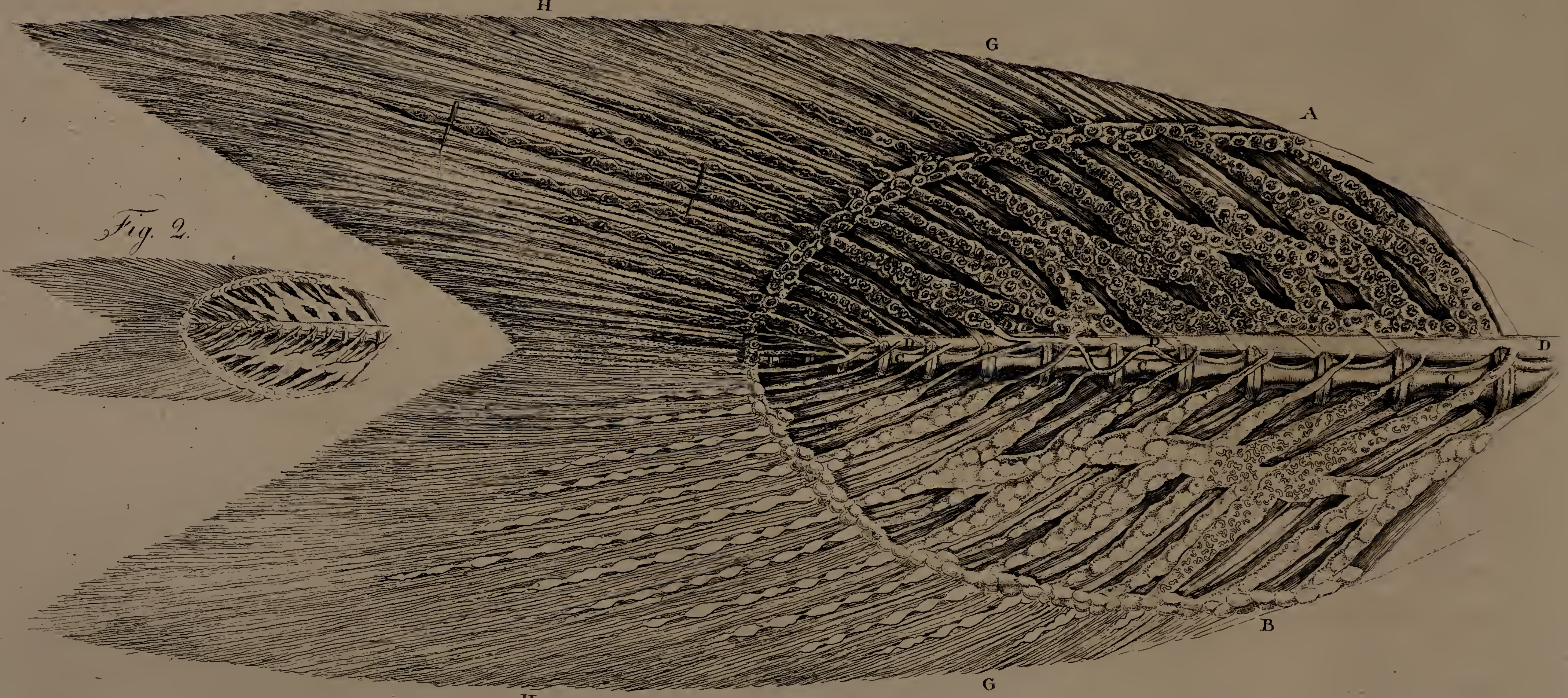
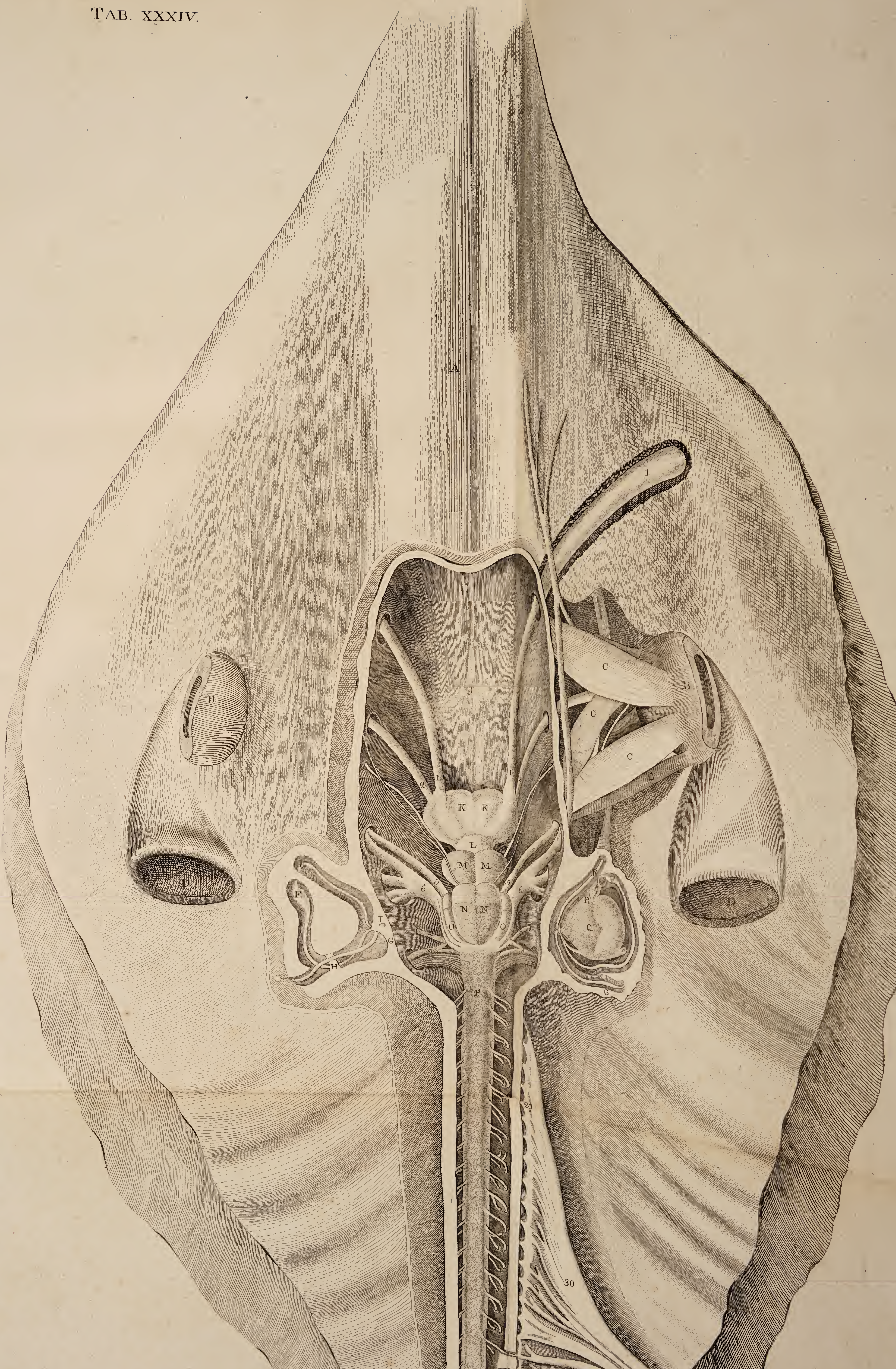


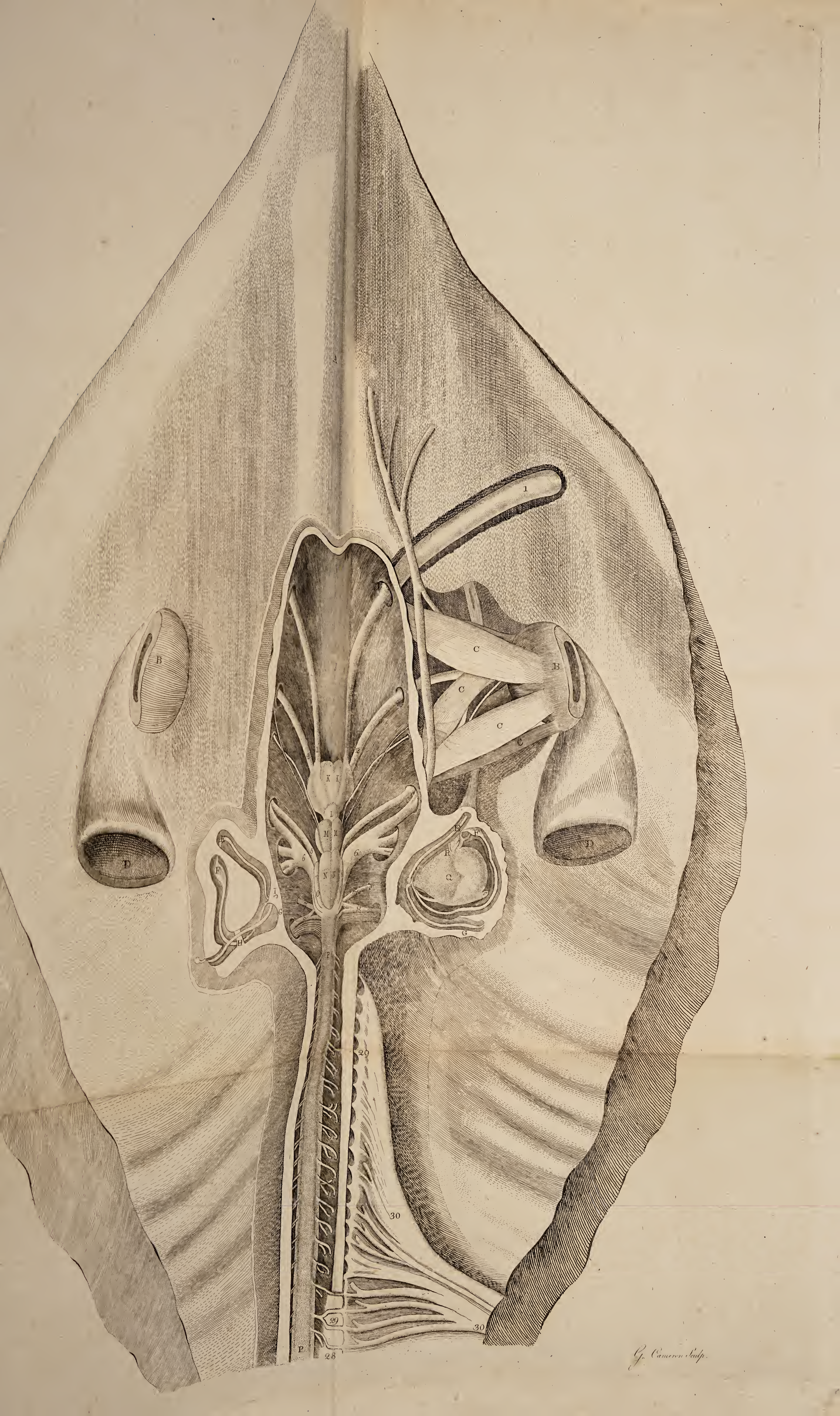
Fig. 2.

TAB. XXXIV.



A. Fyfe Delt.

G. Cameron Sculpt.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G. Cameron Sculp.

TAB. XXXV

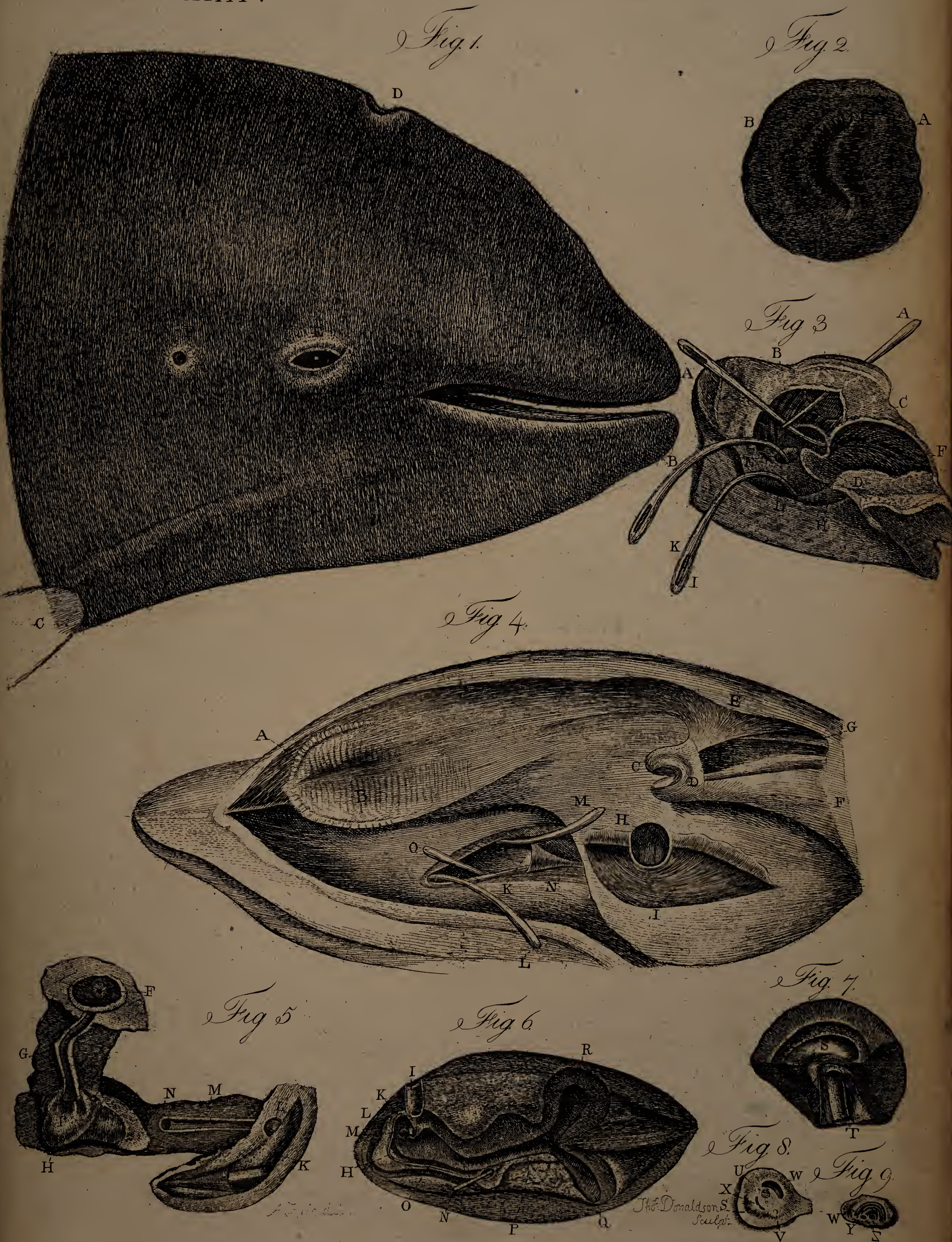
Fig. 1.
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Thos. Donaldson Sculpt.

TAB. XXXVI

Fig. 1.

Fig. 2.

Fig. 2.

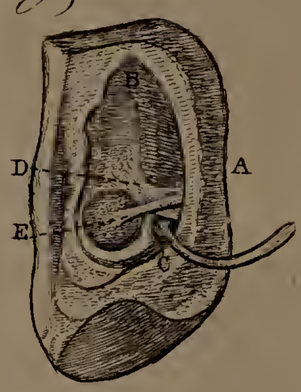


Fig. 3.

Fig. 3.

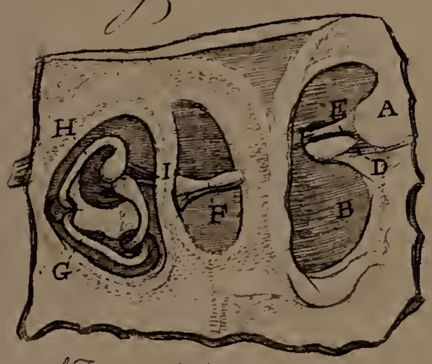


Fig. 4.

A. Fyfe delt. Thos. Donaldson Sculpt.

TAB. XXXVII.

Fig. 1.

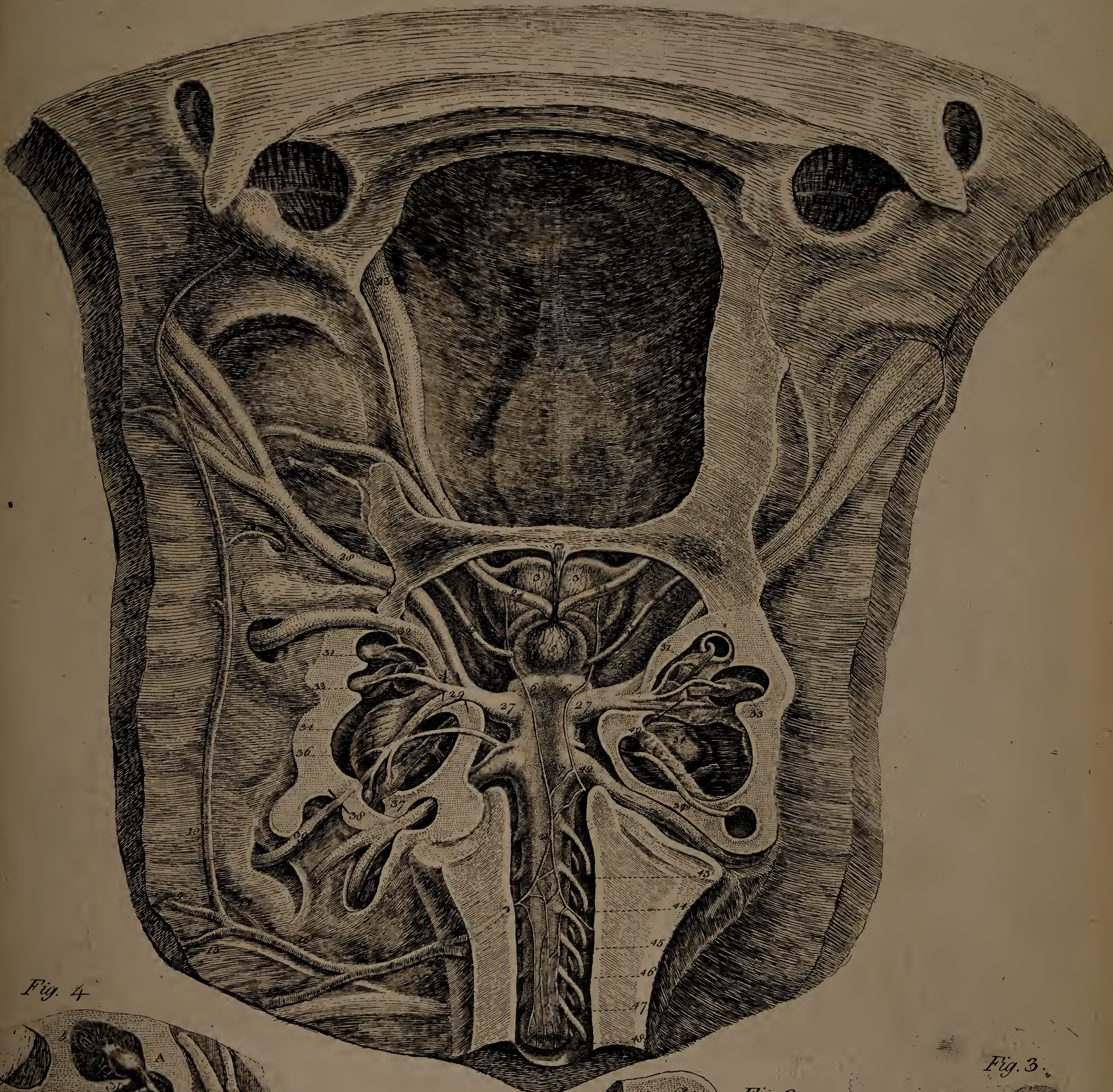


Fig. 4.

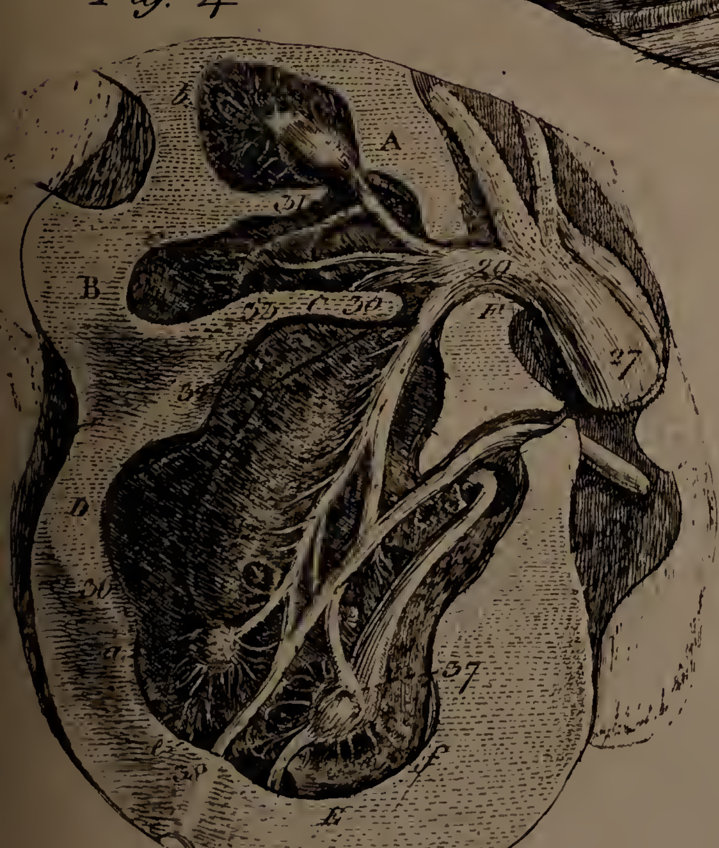


Fig. 2.

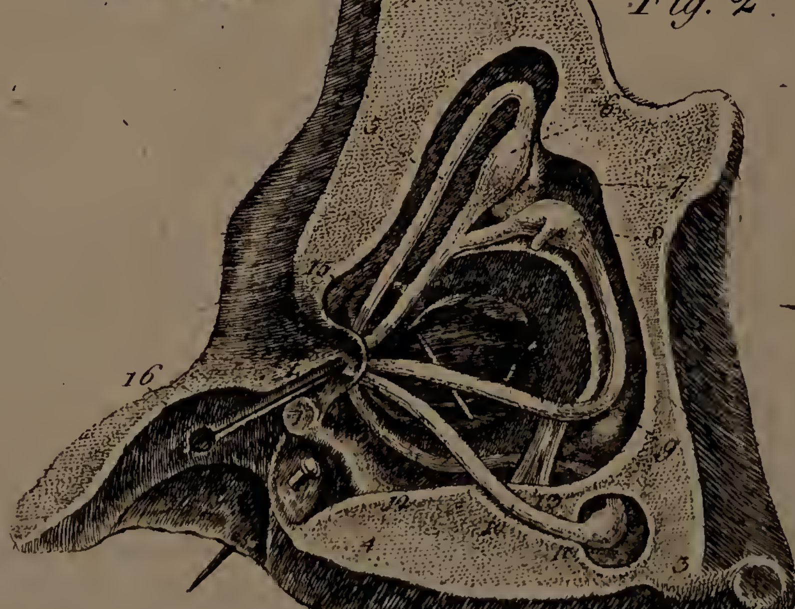


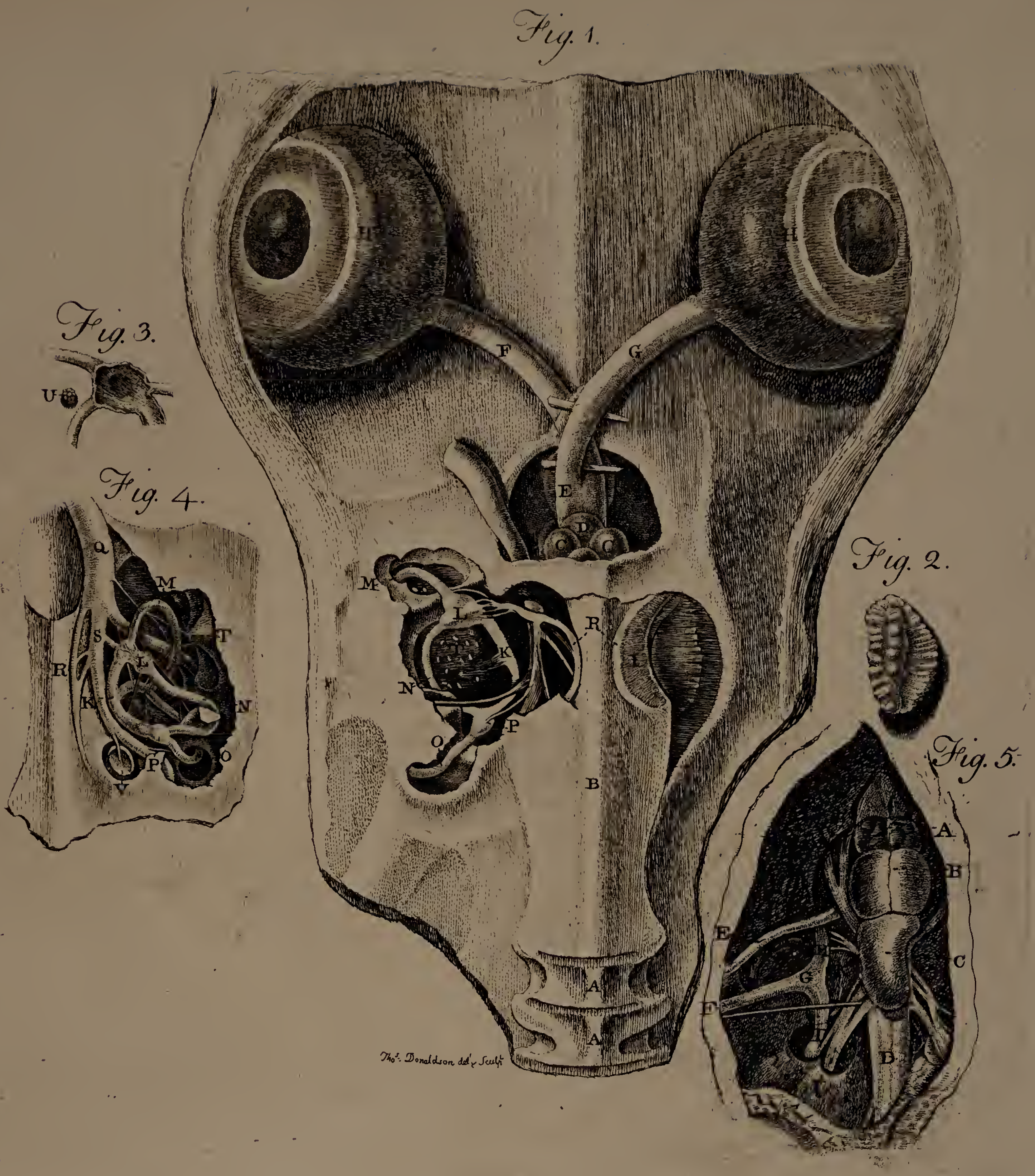
Fig. 3.

Thoˢ Donaldson delt. et Sculpt.

TAB. XXXVIII

A. Fyfe delt. G. Cameron sculp.

TAB. XXXIX.



TAB. XL.

A. Fyfe delent. Thos. Donaldson Sculpt.

TAB. XL. *

Fig. 1.

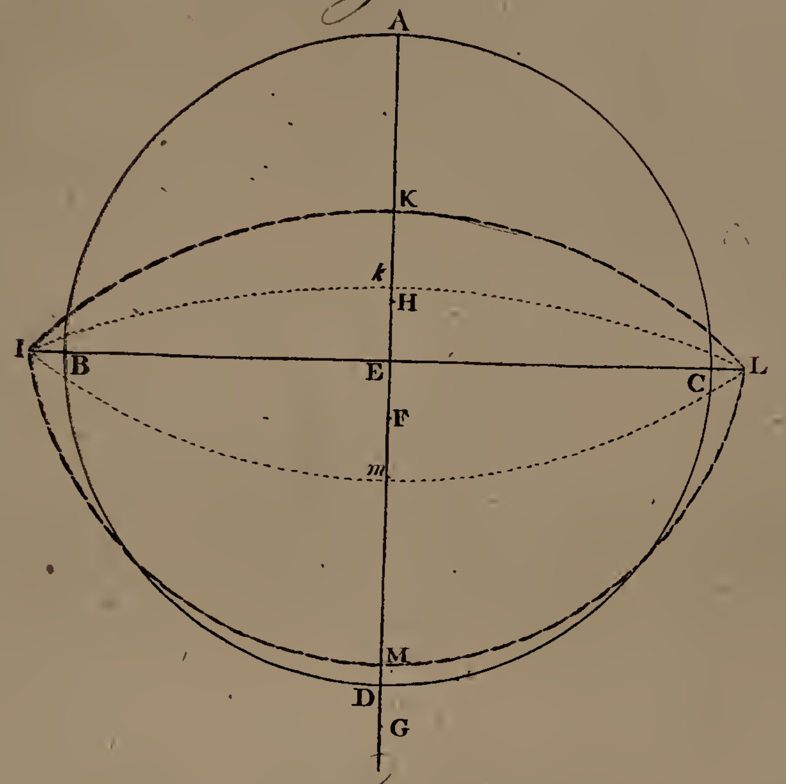
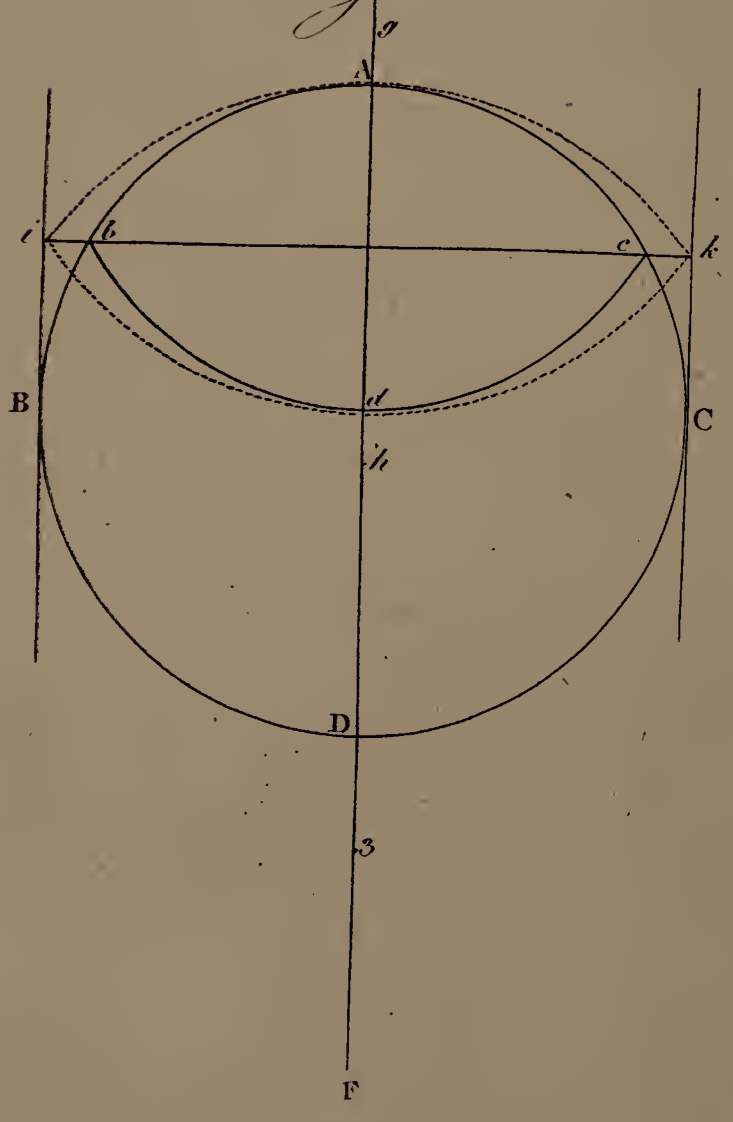


Fig. 2.



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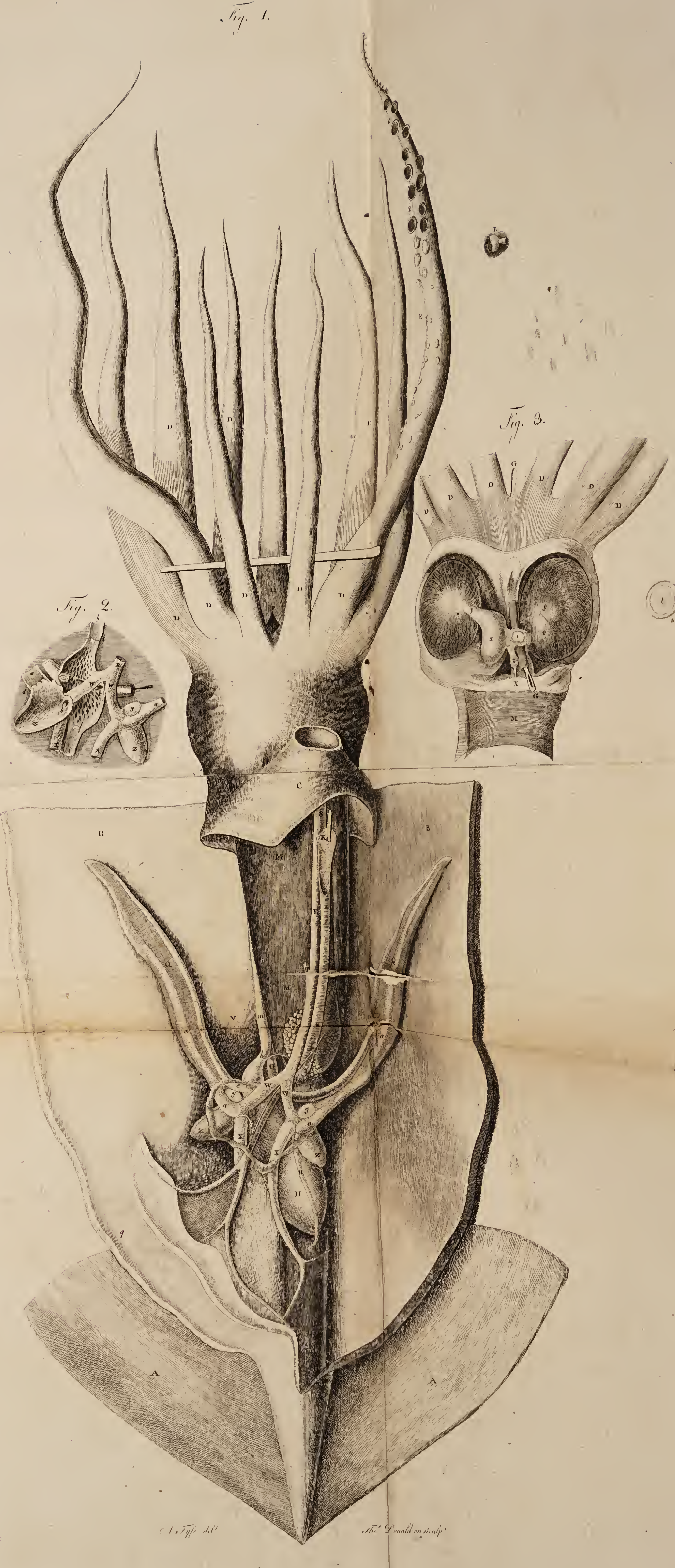
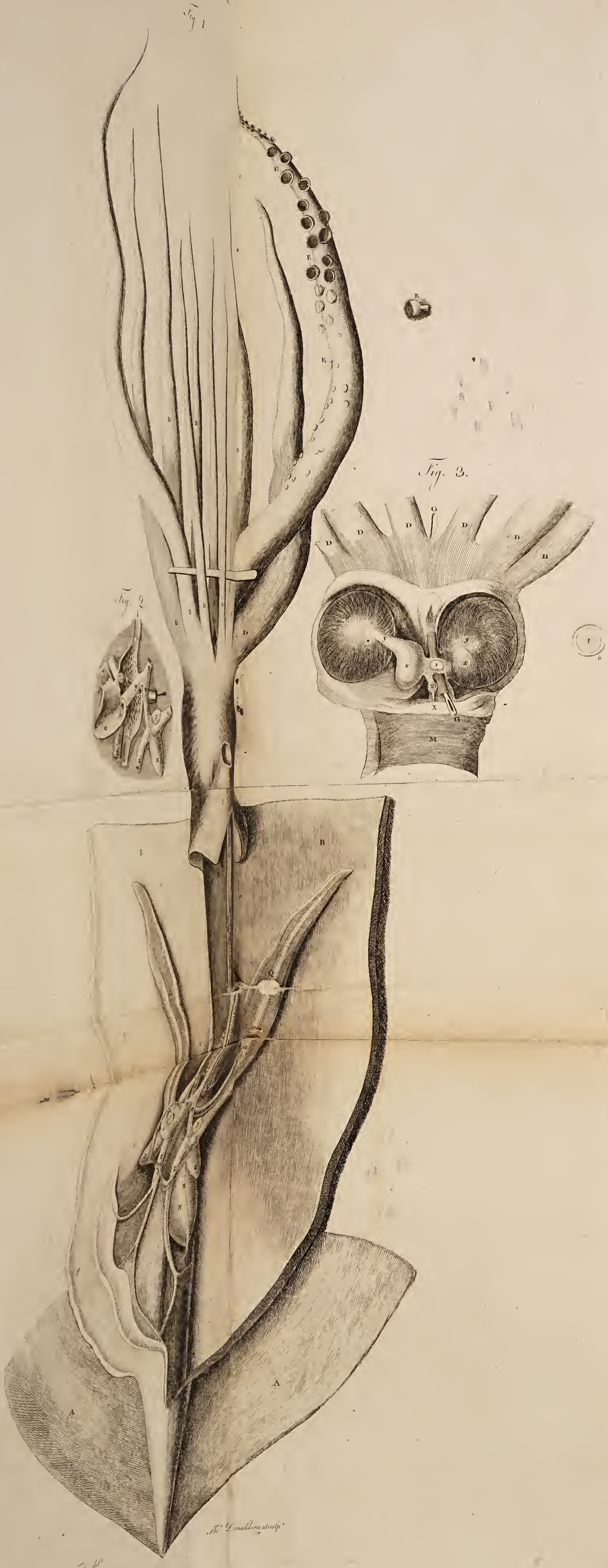


A. Fyfe del^t Tho^s Donaldson sculp^t

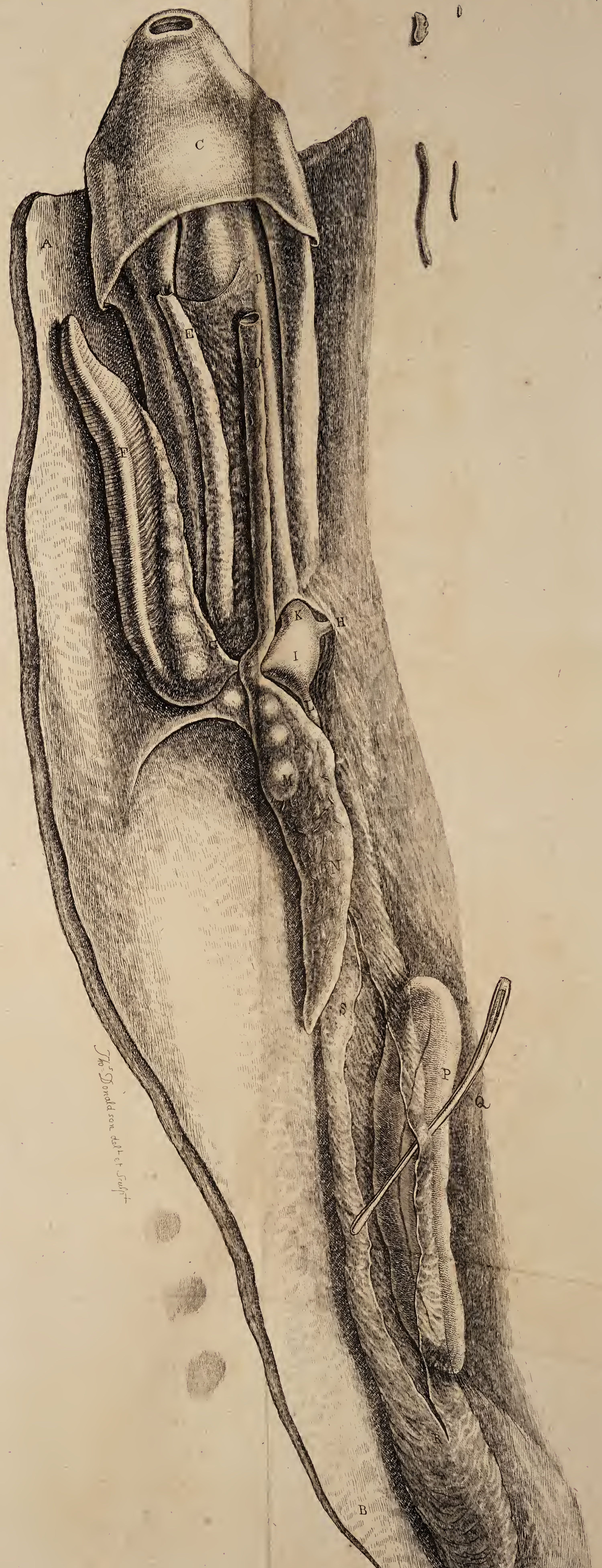
TAB. XLI.

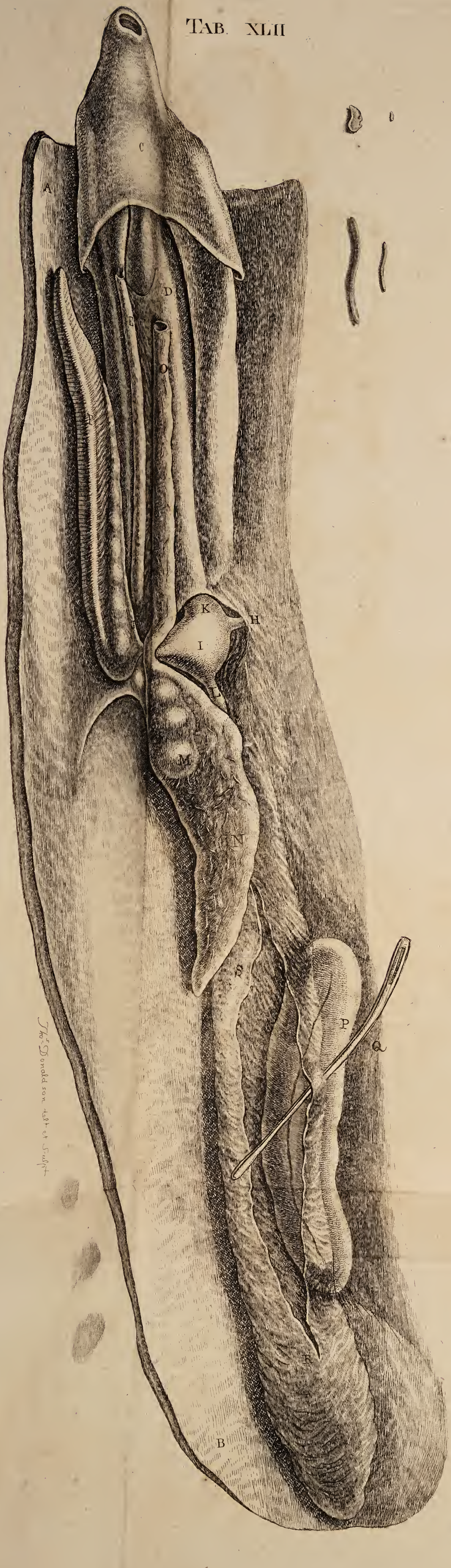


A. Fyffe del.

Thos Donaldson sculp.

TAB. XLII

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Thos. Donaldson delt et Sculpt

TAB. XLIII.

Fig. 1.

Fig. 2.

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TAB. XLIV

A Fyfe del.